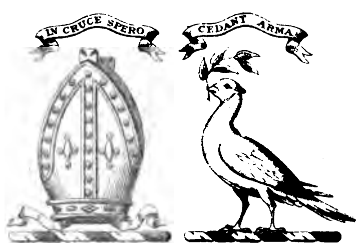
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PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

VOLUME THE FIRST.

1859–1865.

(Authors alone are responsible for the opinions expressed in their respective Papers.)

LONDON:

1865.

PROCEEDINGS

OF THE

GEOLOGIST'S ASSOCIATION.

No. 1.] [Session 1859–60.

Ordinary Meeting, 11*th January*, 1859.

Toulmin Smith, Esq., President, in the Chair.

The following gentlemen were elected Members of the Association: — Mr. Stouffer; John Mitchell, Esq., F.C.S.; R. Mestayer, Esq.; J. Reynolds, Esq.; W. Walford, Esq.; H. Wood, Jun., Esq.; E. L. Prince, Esq.; the Rev. E. Turner, M.A.; C. H. Elt, Esq.

The President then delivered the Inaugural Address. He directed special attention to the importance of finding true facts; remarking that it had been well observed that there were even more *false facts* than *false theories* in the world. He stated that Geology was a science which rested exclusively on a knowledge of the outer world, and none more liable to be hindered by *false facts*. There was none, therefore, in which the gathering up of true facts could be more needed.

There appeared to be good reasons for the work set to itself by the "Geologist's Association;" and beyond the mere advancement of the common stock of knowledge it was to be hoped that the enterprise of this country might be materially helped by its labours, and that in return it would be made the depository of many observations which, but for its existence, would remain buried in the note-books; and further, that by giving right directions to those engaged in extensive works, many conclusions already drawn might be verefied, and many problems solved.

Referring to some observations made by Mr. Salter, in a letter to the "Geologist," Mr. Smith said: As to the collection of "*good facts*," we hope that at every meeting of the Association communications will be made by Members; these will appear in the printed minutes of our proceedings, and being circulated among all our Members, will convey means of comparison and suggestions for research, which are what the local geologist most needs to encourage and enlighten him.

Within six weeks after the first conference 150 gentlemen, many of them well known in connexion with geological science, applied for membership.

With a view to the perfect understanding of various objects which the Association proposed, and the advantages held out to Members, the President entered at some length into the plans for facilitating the collection and exchange of fossils, and the formation of a collection of type-specimens, which should serve amongst other purposes as a key to the larger national collections in this country. He then remarked that the formation of a collection of this character was confessedly difficult; it was easier to accumulate specimens than to bring together only such as should be really useful, but be the difficulties to be encountered what they might, it was hoped, by degrees, that a cabinet which should be truly typical, and always instructive might be formed; and he acknowledged several promises already made of fossils illustrative of the principal formations.

A vigorous protest was entered against the undue use of hard words, on the ground that we possess a language more copious than the Greek or Latin, peculiarly fitted for the compounding of words, and most readily moulded to the expression of new forms of fact and thought.

Some very useful hints to collectors, and some interesting illustrations were then given to show the necessity of proceeding on sound principles and inductions before concluding upon mere appearances, and he concluded by urging the members to use their united efforts for the promotion of the common objects of the Association, being convinced that if the mutual principle were fully acted upon its value would soon be felt, and all would be satisfied that the Association had not been formed in vain.

The thanks of the Meeting were then given to the President for his Address, and it was—Resolved unanimously, that the Address be printed and circulated amongst the Members.

Ordinary Meeting, 8th February, 1859.

The Rev. Thomas Wiltshire, M.A., F.G.S., Vice-President, in the Chair.

The following ladies and gentlemen were elected Members of the Association: — Miss Falkner; Mrs. Wiltshire; Mrs. Hislop; W. T. Wakefield, Esq.; Edmund St. Aubin, Esq.; G. E. Roberts, Esq.; M. Moggridge, Esq.; John Hooker, Jun., Esq.; Samuel Highley, Esq., F.G.S.; H. A. Green, Esq.; J. H. Fuge, Esq., F.R.C.S.; John Hawkins, Esq.; G. Grant Francis, Esq.; H. T. Wood, Esq.; Gilbert Elliott, Esq.; Sidney Crawshay, Esq.; R. W. Williams, Esq.; Mr. G. West; Mr. Watson; S. Salter, Jun., Esq.; F. G. Rance, Esq.; Mr. J. E. Price; H. Pittet, Esq.; J. H. F. Mitchener, Esq.; W. C. Mac Laren, Esq.; E. G. Lobb, Esq.; Mr. Knight; Samuel Lobb, Esq., M.A.; John Henderson, Esq.; Charles S. Haines, Esq.; Thomas C. Fothergill, Esq.; Caleb Evans, Esq.; David Christie, Esq.; William Buckwell, Esq.; James Brunlees, Esq.; W. P. Bonner, Esq.; W. G. Bonner, Esq.; Brackstone Baker, Esq.; A. Bailey, Esq.; Dr. S. L. Phipson; James Pape, Esq.

The Chairman stated that in consequence of the urgent representation of several of the Country Members, in reference to their exclusion from the Ordinary Meetings of the Association, the General Committee had felt it to be their duty to recommend that the rules in that respect be so amended as to admit Country Members to such Meetings, and that a requisition had been signed by six Members, calling on the Secretary to make the next Ordinary Meeting a Special Meeting for the purpose of amending the rules in accordance with the recommendation of the Committee; and also to alter the day of meeting from the second Tuesday to the first Monday in each month, an alteration which became necessary in providing suitable rooms for the Association.

The Secretary reported the following donations towards the Library and Museum of the Association:—

"The Abstract of the Proceedings of the Geological Society of London, 1858-9." By T. R. Jones, Esq., F.G.S.

"The Geologist," for February, 1859. By the Editor, S. J. Mackie, Esq., F.G.S.

"The Flora and Fauna of the Geological Systems." By G. H. Morton, F.G.S. From the Author.

"A Treatise on the extraction of the Precious Metals by means of Mitchell's Patent Amalgamating Machinery." From the Author, J. Mitchell, Esq., F.C.S.

A Collection of Minerals. By Messrs. Mitchell and Rickard.

A Paper was then read by Hyde Clarke, Esq., D.C.L., on Geological Surveys of the British Isles by the Members of the Association, in which he sketched out a plan for the organization of local committees in conjunction with the Association, by which the work of the Government surveyors and others labouring in the geological field might be usefully followed up, and supplemented by the bringing together of new facts, as local circumstances might favour their collection. He adverted to the valuable services which had been rendered to the science by ladies, and mentioned several whose names were well known as accomplished geologists.

He believed that much remained to be done, in more minute classification of the strata, &c., by local researches, and that much good was to be effected by announcements of new minerals, particularly such as would be useful as manures, for building-materials, or in connexion with the manufactures; as well as by notice of such operations as new mines, quarries, wells, pits, railways, roads, tunnels, &c.; of landslips, observations on springs, on thermal, superficial, and subterranean waters; electro-magnetic observations on mineral bodies; earthquakes in particular districts; the rates of erosion on shores, and of new depositions; the like of river-operations; of recent and ancient abrasions; and many other particulars, which would be not only interesting as bearing on points of theoretical geology, but as likely to throw light on questions of great practical and economic importance.

From these records Mr. Clarke thought valuable reports might be drawn up, from time to time, which would exhibit the progress of geological knowledge; and that thus a really useful work would be effected by the Association.

Several promises of Papers were announced.

Ordinary Meeting, 8th March, 1859.

The Rev. Thomas Wiltshire, M.A., F.G.S., in the Chair.

It was stated by Mr. Wakefield, one of the Honorary Secretaries that in consequence of the resignation of the Presidency by Toulmin Smith, Esq., it had devolved upon the General Committee to exercise the power conferred on them by Rule XXXII. for the filling up of vacancies which might occur in the offices of the Association, and that they had accordingly requested the Rev. Thomas Wiltshire, one of the Vice-Presidents, to accept the office of President, and that he had much pleasure in stating that that gentleman had acceded to their request.

The Chair was then taken by the President.

After the reading of the Minutes of the Meeting of the 8th February,

The President stated that it had been considered necessary, in consequence of the urgent representations of several of the Country Members, to rescind Rule V., which excludes Country Members from the Ordinary Meetings, and to vary Rule VI. by the omission of the word "Town" at the beginning. The Rule so altered would then state the privileges of all the Members, whether Town or Country.

The Requisition, duly signed, calling on the Secretary to convene the Meeting with a view to this and to an alteration as to the day of meeting having been read, the question as to rescinding Rule V. and the modification of Rule VI. was put to the vote and carried unanimously.

It was then put to the Meeting that Rule XXIX., as to the day for the Ordinary Meetings of the Association, be altered by the substitution of the words *First Monday* for *Second Tuesday;* which was also carried, and the Rules were declared to be amended accordingly.

The following ladies and gentlemen were elected Members of the Association:—W. S. Cross, Esq.; Joseph Yelloly Watson, Esq., F.G.S.; Mr. R. C. Taylor; the Rev. J. Alloway, B.A.; Mr. G. E. Boggis; G. R. Ritchie, Esq.; Mr. T. Bennett; John Noyes, Esq.; Mr. T. V. Robson; Mr. W. T. Sutton; Mr. John Cliff; Mr. W. Myers; Mr. G. Jackson; W. Cunnington, Esq., F.G.S.; Mr. C. W. Crocker; E. P. Wilkins, Esq., F.G.S.; Rev. G. B. Adam, B.A.; Richard T. Manson, Esq.; I. N. Lockyer, Esq.; Rev. J. S. Henslow, F.G.S., &c., &c., Professor of Botany in the University of Cambridge; Mr. Enoch Walker; Rev. J. S. Marsden; Mr. J. R. Gregory; Mr. Thomas Purdue; Mr. Don; Rev. Thomas H. Brown; P. L. Simmonds, Esq., F.R.G.S.; H. Duckworth, Esq., F.G.S.; John Darlington, Esq.; Rev. L. H. Mordargue; C. F. Pocock, Esq; G. Henslow, Esq.; Rev. T. F. Statham, M.A., F.G.S.; Mr. Cruickshank; Mr. Michael Carty; Miss Ann Tayler Slatter; Richard James, Esq.; G. T. Chambers, Esq.; J. Cumming, Esq.; H. L. Herroun, Esq.; Mr. John Lambley; P. Badcock, Esq.; James Yate Johnson, Esq.; Miss Mac Neill; W. H. Smith, Esq.; Mrs. Jane Bowles; Mr. James Taylor.

The following donations to the Library, from Hyde Clarke, Esq., V.P., were announced:—"A Treatise on Copper Smelting." By Hyde Clarke, Esq. "The Progress of Mining in 1855." By J. Yelloly Watson, F.G.S. "The Recent Brachiopoda." By S. B. Sowerby, F.L.S.

"The Geologist," for March, 1859. From S. J. Mackie, Esq., F.G.S.

Professor J. Tennant gave a lecture on Mineralogy applied to Geology. The lecturer stated that as many as 520 species of minerals were described in one English treatise on the science; and, when any one looked at a map of the world and compared the small area of the British Isles and their mineral wealth with the extent of such territories as that of Canada and Hudson's Bay, and the treasures to be there probably discovered, he must perceive the importance of some acquaintance with the science of mineralogy. Australia, a few years since, was only known as containing a few sheep-walks, and as a penal settlement. In 1851, a piece of stone was received in London and placed in the Great Exhibition, where it created much sensation. It was a gold nugget. Such nuggets had been frequently picked up in Australia; stones containing the yellow metal had been built into walls and houses; but no one had, previously to this time, regarded them. Some thought the metalliferous substance to be iron-pyrites, others that it was copper-pyrites; but if these persons had been acquainted with a very simple test—a common file—they could have easily ascertained the difference between pyrites and gold.

The rapid progress of the colony since this discovery was familiar to every one, and the history of the gold-nugget trade would display prominently the value of observant habits. The lecturer then described the various large nuggets which had been brought into this country, the largest being four feet two inches long by ten inches wide. This was melted and produced fine gold of the value of 6,905*l.* 12*s.* 9*d.*, only twenty-one ounces of stony matter remaining.

Diamonds in the rough state had been thrown aside by the gold-seekers, and many other valuable substances were frequently wasted in ignorance of their nature and properties.

The most interesting part of mineralogy was crystallography, and the lecturer gave illustrations of the methods of distinguishing crystals by their forms, fracture, frangibility, degrees of hardness, &c.

Some specimens of cryolite from Greenland, were exhibited, to show the importance of the study of mineralogy, in developing the means of cheapening useful commodities. Aluminium, at the time of the Paris Exhibition, could not be obtained for less than 4*l.* per ounce. It was soon afterwards offered for 2*l.* per ounce; but, since cryolite had been used, it was reduced to less than 15*s.* per ounce. This was an important metal, and although hitherto only known as a curiosity in the laboratory, would probably, before long, become of the highest commercial importance.

The lecturer concluded with some statistical accounts of the values and annual produce of the chief British minerals.

Ordinary Meeting, 4th April, 1859.

Hyde Clarke, Esq., D.C.L., Vice-President, in the Chair.

The Minutes of the Meeting of the 8th March, 1859, were read and confirmed.

The following ladies and gentlemen were elected Members of the Association:—Edwin Howard, Esq.; Algernon Bathurst, B.C.L.; Ed. P. H. Vaughan, Esq.; T. W. Butler, Esq.; W. Gray, Esq.; Mr. W. Bridger; W. Addams, Esq., F.G.S.; Herbert Crawshay, Esq.; Mr. John Curry; Mr. Graham Yool; Henry Crace, Esq.; Mr. Ralph G. Poulton; R. R. Prosser, Esq.; Mr. Thomas Spiller; John Studdy Leigh, Esq.; Mrs. E. Bohn; John Wickham Flower, Esq.; Mr. Alexander Millar; Mark J. Lansdell, Esq., F.C.S.; George R. Prosser, Esq.; Dr. J. J. W. Watson, F.G.S.

The following donations to the Library and Museum were announced:—

Two Pamphlets on "Certain new Genera of British Crinoids." From Ed. Wood, Esq., F.G.S.

"The Geologist," for April, 1859. From S. J. Mackie, Esq., F.G.S.

Extracts from the "Journal of the Chemical Society." By W. H. T. Allen, Esq.

Extract from the "Quarterly Journal of the Geological Society," on the occurrence of *Graphularia Wetherellii* in nodules from the London Clay and the Crag. From the Author, N. T. Wetherell, Esq.

A tooth of *Mastodon giganteum*, a coral (*Cyathophyllum*), and thirty-eight species of shells from the Tertiary deposits of North America. From J. Pickering, Esq.

An interesting selection of fossils found in the London Clay, in the neighbourhood of Highgate, and at Sheppy. By N. T. Wetherell, Esq.

The President stated that, in accordance with the wishes of several of the Members, the General Committee had under consideration the establishment of short courses of Lectures on Geology, Mineralogy, and other allied subjects, and that they would be glad to receive the names of any of the Members who might be desirous of joining such classes.*

The President, the Rev. Thomas Wiltshire, M.A., then read a Paper on the Red Chalk of England. It was stated that the Red Chalk occurs *in situ* only in the counties of Yorkshire, Lincolnshire, and Norfolk. It is first seen at Speeton, about six miles from Flamborough Head, in Yorkshire, where it rests uncomformably upon the Speeton-clay, and underlies the white chalk, being there about thirty feet, which appears to be the greatest thickness to which it attains. It is traceable from Speeton in a westerly direction for about twenty miles, and then, turning at a sharp angle, proceeds across Yorkshire towards the south-east, and disappears below the marsh-land about seven miles to the west of Hull. It reappears at Ferraby, in Lincolnshire, and from thence may be traced across Lincolnshire till it is lost in the Wash. On the south shore of the Wash, at Hunstanton, in Norfolk, it is again found, and may be traced from that place to a few miles north of Lynn, where it is seen no more. In Lincolnshire and Norfolk it underlies the white chalk and rests upon a dark pebbly mass, which is supposed to belong to the lower greensand. At Hunstanton it is only four feet in thickness, and assumes a different character from that which it presents at Speeton, being much harder, darker in colour, and containing pebbles, which are not seen in the red chalk of the latter place. The red chalk appears to be very fossiliferous, containing serpulæ, terebratulæ, corals, and sponges, belemnites, &c., and from the circumstance that some of the belemnites are of the species characteristic of the gault, the red chalk was regarded by the author as the equivalent of that formation. A curious circumstance was mentioned in connexion with this subject. Although the red chalk does not appear *in situ* except in the localities above mentioned, it has been found in the form of rolled fragments in the drift at Muswell Hill, a fact which would seem to point to the conclusion that it must

* The Committee desire to acquaint Members generally, that S. J. Mackie, Esq., F.G.S., has consented to deliver, on Monday Evenings, commencing 9th May, 1859, a course of twelve lectures on Elementary Geology, for which a fee of five shillings has been determined on. Members desirous of attending the course are requested at once to send in their names to the Secretaries.

at one time have existed in large masses over a considerable tract of country. The fragments are not to be distinguished in general character nor by the fossils they contain from the red chalk of Hunstanton. A seam of red-coloured clay is also occasionally found in the gault of the southern counties.

The paper was illustrated by an extensive suite of specimens from the cabinets of Dr. Bowerbank, N. T. Wetherell, Esq., and the Author.

An interesting discussion followed the reading of the Paper, in which the Chairman, N. T. Wetherell, Esq., Professor Tennant, F.G.S., S. J. Mackie, Esq., F.G.S., E. Cresy, Esq., W. T. Rickard, Esq., and several other Members and gentlemen present took part.

It was announced that on Monday, the 2nd May next, S. J. Mackie, Esq., F.G.S., would read a Paper on the "Geology of the South-East of England."

NOTE.—The President's Paper will be printed and circulated amongst the Members of the Association.

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

No. 2.] [Session 1859–60.

Ordinary Meeting, 2nd May, 1859.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected Members of the Association :—John Jones, Esq. ; John Lock, Junr., Esq. ; and the Rev. J. Deck.

A paper was then read by S. J. Mackie, Esq., F.G.S., "On the Geology of the South-East of England, in illustration of the Value of Theoretical ideas in Geological investigations."

The Author commenced by observing, that it was a common fallacy to ridicule theories, for that, indeed, most practical operations were really based upon theoretical considerations ; he hoped, therefore, by dealing with a portion of the cretaceous rocks in their general bearing, to be able to shew the equal importance and essential value in Geological investigations of *theoretical ideas,* as the grounds upon which to store up and arrange accumulation of facts, through which such theories must ultimately be established as conclusive deductions in the marvellous history of our planet, or demolished as untenable, to give place to other and better speculations.

For this purpose the Author selected the South-Eastern district of England, as containing within its limits more intelligible grounds for speculation and theorizing than any other portion of our island, and having the advantage also of being more readily accessible.

The general physical characters of the area, known under the term of the South-East of England, were then briefly described—namely, the concentric circular out-crops of the cretaceous strata broken by the English Channel; the Wealden central mass; the abrupt chalk-escarpments surrounding, and the lines of hill-ranges, and flexures within the Wealden area; the quaquaversal dip of the beds away from the Wealden centre, and the cross-valleys and river-gorges cutting through the chalk-downs.

After describing the successive sub-divisions of the cretaceous rocks, and pointing out from their distinguishing mineral characters and their characteristic fossils the probable conditions under which these strata were formed, the various rocks were compared in their order, first with the conditions of deposit that would happen with an *uprising* sea-bottom, with the effects of which they totally disagreed, and then compared with the probable successive occurrences of a gradual *depression*, of which the coincidence was visibly interrupted at certainly three particular stages of cessation or of temporary and slight uplift.

It was then shewn from the disposition of the lines of hills within the Wealden area, and the river-gorges, and cross-fractures of the surrounding chalk escarpment, that those lines of elevation or fracture were dependant on mathematical principles (in accordance with the views of Mr. W. Hopkins), and indicated the Wealden area as an area of weakest resistance to the uplifting forces at the time of its upheaval into a central dome; and then the theoretical questions of the former existence of a Wealden island (as alluded to by Mr. Prestwich), in the cretaceous and tertiary oceans, whether the original continuous extension in their full thickness of the successive domes of the lower greensand, gault, and chalk strata over the now denuded area of the Weald, or whether those strata thinned out against, or over such an island, were set prominently forth in order to shew not only what was yet necessary to acquire for the proper elucidation of those interesting theoretical points, but more essentially how necessary it was in the accumulation of facts, and in the observation of a district, to have some probable hypothesis upon which to ground the objects and purposes of our investigation.

The old paleozoic axis extending from the Ardennes, by Marquise, pointed out by Mr. Austen, was considered in its probable bearings on these subjects, as were also the conditions of the foreign equivalents in neighbouring regions. In numerous instances of variable superposition we have indisputable evidence not only of successive changes of levels, upheavals, or depressions, during the formation of the cretaceous series, but of unequal and variable changes, as also that such changes were variable both in time and in range of space.

If there were a Wealden island at the commencement of the cretaceous period, as has been presumed, the sediments formed around it must have been thickest as they receded from its shores, and were accumulated in the deepest water. The question, then, of the continuity in this full thickness of the cretaceous beds over the Weald resolves itself into these items: Do the cretaceous strata shew indications of thinning out in any particular direction? and do the lowermost cretaceous beds present different angles of inclination or dip from the upper strata, *i.e.*, for example: Does the lower greensand, &c., differ in dip from the chalk?

The Author inclined to think from the evidence he passed under review, that there were three periods of cessation or interruption in the deposit of the cretaceous rocks, and that there were some grounds for supposing that the lower cretaceous strata might not have originally extended in their full development over the Wealden district. The question was still open to discussion, and all stratigraphical observations made on the rocks of the South-East of England were comparatively valueless, if made without due regard to this essential consideration.

In the course of the discussion which followed, and in which the Chairman, Professor Tennant, Mr. Lawson, Mr. Charlesworth, and Mr. Cresy, took part, Mr. Charlesworth called attention to the rarity among the fossils of the chalk, of young specimens of *Ananchytes ovatus;* and he stated, also, that groups of fossils lying together are uncommon in that formation.

Some interesting fossils were exhibited by Mr. Charlesworth; among others, a jaw of an ichthyosaurus, measuring thirty-six inches in length, and only one inch and one-eighth at the base.

Ordinary Meeting, 6th June, 1859.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following were elected Members of the Association:—Wm. Spooner, Junr., Esq.; Frederick Braby, Esq.; Mrs. Frederick Braby; George Dale, Esq.; Richard Jones, Esq.; Geo. Smith, Esq.; and John Stabb, Junr., Esq.

The following papers were read:—

1. "On the Eastern boundary of the North Wales coal-field near Oswestry." By D. C. Davies, Esq. On the Government Map, sheet 74, South-East Llangollen, the eastern boundary of the coal-measures is laid down as uncertain because obscured by gravel. The Author considers that recent operations in the neighbourhood may help to define the line more exactly.

Between Wigginton and Lower Wigan, one and-a-half miles from the northern margin of the maps, and one mile east of the present boundary, a thin seam of coal was observed cropping out upon the surface; this led to the sinking of a shaft, when other seams were reached, but owing to the broken nature of the ground the works were abandoned.

Stimulated, however, by the discovery, another shaft was almost simultaneously sunk at Ifton Rhyn, on the north margin of the map, and half-a-mile east of the present line. After passing through twenty yards of soft sandstone a seam of good coal was reached, which continues to be worked with vigour. The strata at this spot inclines at a considerable angle to the east.

Since then as a workman in the employ of Mr. Lovett, of Belmont, was engaged in draining a field at Rhos-y-gadfa (south of Wigginton, as above), he came upon two thin seams of coal with a dip of S.E. by S.

In the later editions of the Government Maps the coal-measures are made to take a bend on the western side of Oswestry, the result, probably, of some observations made on the strike of the beds in the coal-pits a mile south of that town. The strike is S.E. by N.W.;

and supposing no fault to intervene between the works and the town, the present line would be approximately correct. But the Author thinks it more than probable that the little valley of Morda is on the line of a fault, and sees no reason why the shorter of the two faults bearing N.E., which is an upthrow to the east, may not proceed beyond its present termination, as some of the others certainly do.

There is a great difference in the composition of the strata on the eastern and western border of the band marked Permian. At Croeswyllan, on the south side of Oswestry, shafts were sunk some years since to obtain coal, but were abandoned, owing to the great influx of water. The sandstone thrown out of these is often hard and compact in colour, ranging from a buff to a dark brown, with red and blackish streaks, closely resembling the sandstone of the coal-measures.

Half-a-mile east of these shafts, near to Garreg Llwyd, a well has lately been sunk through soft, friable sandstone, of a deep red colour, the same throughout.

From this difference in the nature of the strata, as well as from the general conformation of the surface, the Author is induced to think that the sandstone of the well is the true permian, and that of the shafts the upper sandstone of the coal-measures; and, also, that the boundary of the coal-field, near Oswestry, is now laid down almost as much too far to the west, as in the first editions of the maps it was placed to the east.

2. "On some Peculiar Markings occurring occasionally on the Broken Surfaces of Flints." By N. T. Wetherell, Esq., F.G.S.

These markings exhibited on the fracture of flints the Author had formerly considered to be organic. He now regarded them as structural only, and inorganic.

This paper was illustrated by numerous specimens, and will be printed entire, with a lithographed plate, given by Mr. Wetherell.

3. "On the Fossil Remains of the Mammoth found in the bed of the German Ocean, in the East or South-East portion of England." By Edward Charlesworth, Esq., F.G.S.

Some magnificent mammoth bones, formerly in the possession of the late Captain J. B. Martin, Harbour-master at Ramsgate, were exhibited by Edward Charlesworth, Esq., F.G.S.

These bones, and the circumstances under which they were found, are described by Captain Martin, in "The Transactions of the Geological Society, vol. vi., part 1 (2nd series), page 161.

The following is a quotation from Captain Martin's Memoir :—

"In 1837, while trawling between the two shoals called the Varn and Ridge, covered at low tide with twenty fathoms water, a fisherman suddenly encountered a heavy mass, which proved to consist of enormous bones; the net broke, but a humerus, which I purchased, was secured. The upper articulation is wanting, and that part appears to have been most decayed. It is of a very stony texture, and its interior is filled with marine substances. The following are the dimensions :—

Length from the lower condyle to the fracture	38	inches.
Presumed original length	45	„
Circumference at the upper part of the shaft	31	„
Ditto in the centre	20	„
Ditto around the lower part just above the condyle	31	„
Width across the condyles	10	„

"The Varn and Ridge lie in the mid-sea between Dover and Calais, and form a line of submarine chalk-ridges extending parallel to the cliffs on each side of the Channel, and tending towards the North Sea. The Overfalls and Galloper Sands are continuations of the same line. The flanks of all these submarine ridges are steep. There are deep gullies in the intermediate spaces, filled with patches of boulders, and blocks of various stones and muddy ground. Thus, these interesting remains appear to repose in marine valleys in a similar manner to the analogous bones on land; and it is evident that they are thickly strewed over the bed of the sea in these latitudes. They are never found on the summits of the banks or shoals, but invariably in deep water in the hollows."

The bones exhibited to the Meeting included the following :—

1. The humerus, of which Capt. Martin has given the dimensions above quoted. This bone is not fractured, as supposed by Captain Martin, but the epiphysis, owing to the immature age of the animal, not having been united completely to the shaft has separated. Con-

sidered, in reference to its size and general perfection, this bone is not equalled by any British fossil humerus in the Collections of the great London Museums.

2. Another humerus of the mammoth, rather smaller than the above, but with the epiphysis.

3. A portion of the pelvis of the mammoth, with the cavity for the reception of the head of the femur.

4. A slender tusk well displaying that remarkable twist which is so highly characteristic of the extinct elephant.

5. Another tusk, which its finders had sawn into several pieces to display the condition of the fossil ivory.

Mr. Charlesworth made some general remarks upon these fine fossils in connexion with the history of the elephant-species both living and extinct. He more especially drew the attention of the Members present to the recent serpulæ which were attached in great numbers to these fossil bones, and which were not only interesting as incontestably proving that the bones had been lying in the bed of the sea, but which also conveyed a most important caution in respect of the geological deductions which are sometimes based upon the hypothesis that mere association implies previous contemporaneous existence. There is nothing extravagant in the supposition that some thousands of years hence the bed of the German Ocean, which is more or less one vast charnel-house of mammoth skeletons, may be elevated above the sea, and be accessible to geological investigators. One result of these explorations would probably be the very natural inference that the marine serpulæ and the terrestrial mammoth were living, the one in the sea and the other on the land, during the same geological period. Yet how wide of the truth would be this conclusion.

A discussion followed, in which several of the Members took part.

Mr. Charlesworth afterwards gave a brief account of some extraordinary plesiosauri and ichthyosauri, lately added to the Collection of the York Museum, from the Lias of that coast.

Specimens of *Ananchytes ovatus* were exhibited by the President with a view to throw light on the question raised by Mr. Charlesworth at the last Meeting, as to the rarity of small specimens of this fossil in the Chalk-formation.

The following donations were announced :—

"A Collection of Stonesfield Oolite Fossils." By T. Perdue, Esq.

"A Collection of Iron-ores." By Messrs. Mitchell and Rickards.

"The Geologist," for the May and June, 1859. By S. J. Mackie, Esq., F.G.S.

"The Abstract of the Proceedings of the Geological Society." By T. Rupert Jones, Esq., F.G.S.

"A small quantity of Banded Flints from the Whetstone Gravel-drift. By N. T. Wetherell, Esq., F.G.S.

It was also announced that the President and Mr. Mackie had presented a set of wood-cuts and lithographs, for the purpose of illustrating the President's paper on the Red Chalk of England.

NOTE.—The next Meeting of the Association will take place in October next, when a paper will be read by E. Cresy, Esq., on the Echinoderms of the Chalk. The annual three months' vacation, prescribed by the Rules of the Association, will take place one month earlier than usual this year, in consequence of the Association being unable to obtain the use of their present rooms beyond the end of this present month. Due notice of the new place of meeting will be given. In the meantime Members are requested to retain any specimens which they had intended for exchange or presentation. Letters to the Secretary may be addressed, "GEOLOGIST" Office, 154, Strand.

ERRATUM at p. 9, of No. I. "Proceedings of the Association," line 15 from the top, for "south" read "east."

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

No. 3.] [Session 1859-60.

Ordinary Meeting, 3rd October, 1859.

The Rev. Thos. Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected Members of the Association:—Edward Tindall, Esq.; S. H. Needham, Esq.; C. G. R. Quinet, Esq.; G. Highton, Esq.; J. C. Mansell, Esq.; J. F. Collingwood, Esq.

The following donations were announced:

"The Geologist" magazine for the months of July, August, September, and October, by the editor.

Abstracts of the proceedings of the Geological Society of London, by the Geological Society.

The President stated that the Committee had succeeded in re-engaging the rooms formerly occupied by the Association, at No. 5, Cavendish-square, and that they should be happy to receive donations of typical fossils for the Museum. He also requested that members who were desirous of exchanging specimens would forward them to the rooms of the Society.

A Paper, illustrated by an extensive series of specimens and by a large number of very beautiful diagrams, was then read by E. Cresy, Esq., on the Echinidæ of the Cretaceous formations.

The author commenced by indicating the position of the Echinidæ as a large and important section of the Radiata, and pointed out the several steps in the series which connected the completely circular types with those having a marked tendency towards bilaterality.

He then enumerated the principal characteristics of the order, beginning with a description of the calcareous shell, or test, constituting an internal and integral portion of the animal, being secreted by and enclosed within organised membranes, and participating in the life of the organism, the homologue of the vertebrate-skeleton rather than of the shell of the mollusc. This is composed of ten columns of small plates called ambulacra, and ten of large, known as interambulacra, separated from each other by ten rows of holes, constituting the poriferous zones, the latter being formed by the articulation of a great number of small pieces, and presenting several varieties of form and arrangement. The external plates are studded with primary and secondary tubercles, minute granules, and miliary granulation; the spines are moveably articulated with the tubercles, offering numerous modifications as to size, form, and sculpture, all of which are important in distinguishing the various species. The apical disc at the summit of the test, and the five ovarian and five ocular plates of which it is composed, were referred to, as well as the positions of the two great apertures of the shell—the mouth and the vent, the former being always at the under, and the latter usually at the upper surface of the shell.

The relative value of the external organs in classification was indicated, and the author stated that while the position of the mouth was always basal, and therefore of less importance in classification, the position of the vent formed a character of great importance. In one great section it is within, and in another without the apical disc, and is also more or less external to, and at a greater or less distance from the ovarian and ocular plates. The physiological importance of the position of the external orifices of the organs of digestion and reproduction was dwelt upon as of great value, and as leading to the subdivision of the order into two sections—the Exocyclic and Endocyclic Echinidæ.

The structure of the ambulacra and the poriferous zones was said to afford good characters for grouping the genera into natural families, especially when taken in connection with the position of the vent; while the genera are well defined by the form, number, and arrangement of the spines, the miliary granulation, and position of the vent taken collectively. These again may be subdivided into species by aid of the minute details of structure of the plates, the form, size, and number of tubercles, etc., the arrangement of the pores in the poriferous zones, and the sculpture of the spines.

The author stated that it was not his intention in the present paper to attempt more than an enumeration of the principal points of the generic classification of the Echinidæ of the chalk.

A discussion then ensued on the subject of the paper, in which the President, Professor Tennant, Mr. Charlesworth, and other gentlemen took part.

Ordinary Meeting, 7th November, 1859.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected Members of the Association:—Charles Tomlinson, Esq.; Edmund Jones, Esq.; Wm. Compton, Esq.; Dr. Kalvo; W. H. Bensted, Esq.; John Brent, Esq.

The following donations were announced:—"The Geologist" magazine for the month of November, from the Editor; Abstracts of the Proceedings of the Geological Society of London, from the Geological Society; and several specimens of Stonesfield fossils for the Museum, from Thomas Purdue, Esq.

Mr. Cresy then commenced the second part of his paper on the Echinidæ of the Cretaceous Formations, by describing the characteristics of the several families.

Cidaridæ.—The cretaceous specimens of this family all belong to the genus Cidaris, which is characterized by having the mouth and vent large, and placed opposite to one another, the ambulacra small in comparison with the interambulacra, the spines very large and strong, and in shape cylindrical, fusiform, prismatic, or club-shaped.

The *Diademidæ* include the genera Diadema and Cyphosoma. These are distinguished by having the mouth and vent opposite, and the interambulacra nearly twice the size of the ambulacra.

The *Echinidæ* includes only the genus Echinus. The interambulacra are three times the size of the ambulacra, the poriferous zones are very narrow, the tubercles small, and the spines short.

Saleniadæ.—In this family the genus Salenia is the only chalk exemplar, and is mainly characterized by the great development of the apical disc, and by having the vent not quite central.

The *Echinoconidæ* comprise the genera Discoidea, Galerites, and Caratomus, the chief marks of which are the thin shell, the wide interambulacra, and the straight ambulacra; the mouth also is circular and central, or sub-central, and the spines are small.

The *Echinobrissidæ* includes Catopygus as the only chalk genus characterized by having the mouth small, and in general surrounded by five lobes, and the vent lodged in a sulcus.

Clypeasteridæ includes the chalk genus Nucleolites. In this the shell is thick, the dorsal portion of the ambulacra leaf-shaped, the spines small and short, the mouth large and central.

The *Echinonidæ* comprise the genus Pyrina, having the shell thin and of an oval shape, the mouth nearly central, the vent ex-central, basal, or marginal, the poriferous zones narrow.

The next order is the *Echinocorydæ*, comprising the genera Holaster, Cardiaster, and Ananchytes, having the shell thick and oval, the ambulacra narrow, the vent marginal, and the mouth small and excentral; and finally the *Spatangidæ*, including the genera Micraster, Hemipneustes, and Hemiaster, and distinguished by the heart-shaped shell, the very small spines, and the position of the mouth near the anterior extremity of the shell.

In the course of the discussion inquiry was made whether the paper would be printed at length, but it being stated that the funds of the Association would not at present permit of such an undertaking, involving the lithographing of so many illustrations, Professor Tennant expressed his regret that the Members should not be in possession of so useful a summary, and urged the necessity for their co-operation for the purpose of its publication, and in earnest of his interest would willingly subscribe a sovereign towards it. Several other Members declared their entire concurrence in Professor Tennant's suggestion, and a list of subscribers was formed before the meeting adjourned.

Ordinary Meeting, 5th December, 1859.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentleman was elected a member of the Association —W. S. Clark, Esq.

The following donations were announced:—"The Geologist" magazine for December, from the Editor; Abstracts of the Proceedings of the Geological Society of London, from the Geological Society.

According to one of the laws of the Association, two members were appointed, viz., Professor Tennant and T. G. Rance, Esq., as auditors, to audit the accounts, and to present the yearly statement at the Meeting in January, 1860.

The President stated that since the last meeting the Association had lost a valuable friend in the person of John Brown, Esq., F.G.S., who had prepared a paper which was to have been read that evening. Under these circumstances the Committee had thought it respectful to the memory of Mr. John Brown, that his paper (which had been forwarded to the President) should not be read until the next meeting in January. It was announced that Professor Tennant, F.G.S., had kindly volunteered at very short notice to give a lecture on siliceous nodules in the various formations.

Professor Tennant commenced by some observations on the large proportion in which silica enters into the composition of rocks, constituting one-half part of granite, one-third part of syenite, nine-tenths of quartz, and three-fourths of greensand. He then described the enormous amount of silica in the flints of the upper chalk, and called attention to the peculiarity which distinguishes the beds of flints in Kent and Sussex from those of Yorkshire. In the former they are of dense structure; in the latter mostly of a porous character, taking regular forms, not unlike those of many modern sponges.

Some remarks were then made on Dr. Bowerbank's theory that the great mass of the flints found in the chalk are true sponges. A theory to which Professor Tennant said he was inclined to subscribe. He pointed out as an illustration of its possible truth, and as a proof organic remains may be enclosed in silica, the well known appearance of moss-agates, sections of which procured from Oberstein, cannot under the microscope be distinguished from sections of certain modern sponges. Professor Tennant also drew attention to the difference in the flints of volcanic and aqueous rocks; the former being destitute of, whilst the latter abound in, organic remains.

After alluding to the beds of chert in many of the formations, such as the Portland-rock, greensand, etc., he advocated the view that the Paramoudræ, of Ireland, are nothing more than enormous silicified sponges, and concluded with an account of the hollow flints found on Salisbury Plain, the core of which when examined under the microscope is seen to be composed of a mass of delicate spicules.

A discussion by several of the members followed, during which the President directed attention to a circumstance, which Mr. Charlesworth confirmed, viz., that a mass of flint when surrounding the base of a ventriculite, never envelopes the whole of the root of the ventriculite.

Mr. Charlesworth made several remarks, with a view of explaining this phenomenon, and at some length entered into reasons for disagreeing with the views of Dr. Bowerbank as to the spongy origin of many of the Chalk flints.

The members were reminded that the next meeting on January 2nd, 1860, would commence at half past six o'clock, when the officers for the year ensuing would be elected, and the paper of the late Mr. Brown on Fossil Mammalian remains lately found in Essex, would be read.

ERRATUM.—Members are requested to add the figure 1 before each of the figures at the top of the page in No. 2 of the Proceedings of Geologists' Association.

*** The annual subscriptions for the year 1860 are due in the month of January.

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

No. 4.] [Session 1859-60.

Annual General Meeting, 2nd Jan., 1860.

The Rev. Thos. Wiltshire, M.A., F.G.S., President, in the Chair.

The Annual Report of the Committee was read, as follows:—

Report.

The Committee of the Geologists' Association, in presenting their first annual report, enter upon the work with feelings of no slight pleasure, seeing that they can refer to the deeds of the past, and thence hopefully augur for the future. The success of the Association has exceeded the expectation of its promoters. Originally founded with a view of placing the science of Geology in the hands of that large class who have neither the time nor the money for mastering the subject and becoming Fellows of the Geological Society of London, it has been assisted and encouraged by many well known names, who have become members not so much for the sake of the benefit they might themselves derive, as for the aid they could impart to others.

In the original prospectus it was stated that the Association would endeavour to promote the reading of papers, the giving of lectures, the formation of a typical collection of specimens, the exchange of fossils amongst the members, and the gathering together of sound geological books.

In all these matters the spirit of the prospectus has been carried out as far as the funds would permit. Papers have been read at the meetings of the Association, and their reading has been followed by discussions, in which various opinions were given and facts noted, useful alike to the student and the amateur. Of these papers the following are the titles and the names of the authors:—

"The Finding of True Facts," by Toulmin Smith, Esq.

"On Geological Surveys," by Hyde Clarke, Esq.

"On Mineralogy applied to Geology," by Professor Tennant.

"On the Red Chalk of England," by the Rev. Thos. Wiltshire.

"On the Geology of the South East of England in Illustration of the Value of Theoretical Ideas in Geological Investigations," by S. J. Mackie, Esq.

"On the Eastern Boundary of the North Wales Coal Field, near Oswestry," by D. C. Davies, Esq.

"On Some Peculiar Markings Occurring Occasionally on the Broken Surfaces of Flints," by N. T. Wetherell, Esq.

"On the Fossil Remains of a Mammoth Found in the Bed of the German Ocean, in the East or South East Portion of England," by E. Charlesworth, Esq.

"On the Fossil Echinidæ of the Chalk," by E. Cresy, Esq.

"On the Siliceous Nodules in the Different Formations," by Professor Tennant.

Several of these papers have been printed entire, and with illustrations, the latter being the gifts of the authors of the papers. The design of giving class lectures has also been carried out under the superintendence of Mr. Mackie, who in two separate courses of six lectures each has imparted to the student not merely the elementary, but the deeper branches of geological reasoning.

The formation of a typical collection of fossils is in progress. The work proceeds satisfactorily; and the collection will no doubt shortly become of considerable extent, since many members have promised to contribute specimens as soon as a proper cabinet could be obtained; which has now been done.

The exchange of specimens proceeds somewhat more slowly; but already several boxes have been forwarded to the Association, and as soon as a few more arrive, the Committee hope to be able to distribute the contents amongst the corresponding members,

Several works are in the library. Amongst them are "The Geologist" magazine; Abstracts of the Proceedings of the Geological Society of London; The Flora and Fauna of the Geological Systems.

The occupation of rooms was originally a cause of much perplexity to the Committee, as it was difficult to meet with any suitable, either in position or rent. The Committee, however, have at length agreed to rent the present apartments of the College of Dentists, at 5, Cavendish Square.

The number of members is very satisfactory, nearly 300 ladies and gentlemen having joined the Association: of these several are life members.

The Committee have to regret the loss by death of two members, one of whom was a firm friend to the Association, and has left to it a legacy of £100, which will be in a short time paid by his executors.

The finances are in a good state, and the accounts show a balance in the hands of the Treasurer of £44 11s. 9d., as will be seen from the report of the auditors.

In conclusion the Committee beg to recommend the following list of officers for the year 1860.

PRESIDENT.

Rev. T. Wiltshire.

VICE-PRESIDENTS.

J. Pickering, Esq.	J. Tennant, Esq.
Toulmin Smith, Esq.	C. Woodward, Esq.

TREASURER.

W. Hislop, Esq.

GENERAL COMMITTEE.

E. Cresy, Esq.	S. J. Mackie, Esq.
J. Carter, Esq.	B. Marriott, Esq.
F. J. Furnivall, Esq.	W. T. Rickard, Esq.
J. Grant, Esq.	J. E. Saunders, Esq.
H. T. Kempton, Esq.	J. L. Shuter, Esq.
T. Lovick, Esq.	J. E. Wakefield, Esq.

HONORARY SECRETARY.

W. N. Lawson, Esq.

The President explained that the adoption of the report would carry the election of the officers recommended therein, and it was resolved unanimously that the report be adopted. Professor Tennant then submitted the following balance sheet, signed by the auditors, and recommended that the life subscriptions should be invested from time to time, so as to form a permanent fund.

GEOLOGISTS' ASSOCIATION BALANCE SHEET.—1859.

To subscriptions from Three Life Members, at Five Guineas	15	15	0	By Stationery, Postage, &c.	18	5	8
To Subscriptions from Five Life Members, at Three Guineas	15	15	0	By Printing, Advertisements, &c.	37	16	10
To Subscriptions and Entrance Fees from 218 Annual Members	93	15	0	By Rent and Attendance	19	3	9
				By Cabinet and Cases	5	7	0
				By Balance in Treasurer's hands	44	11	9
	£125	5	0		£125	5	0

(Signed) JAS. TENNANT,
T. GEO. RANCE.

29th Dec., 1859.

It was resolved, That the recommendation of Prof. Tennant be referred to the General Committee, with instructions to take the necessary steps for carrying it into effect.

Ordinary Meeting, 2nd Jan., 1860.

The Rev. T. Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—Capt. C. S. Bradley; L. Cooke, Jun., Esq.; R. Mortimer, Esq.; H. C. Tomlin, Esq.

The following donations to the Association were announced:

"The Geologist" for January. From the editor.

"Abstracts of Proceedings from the Geological Society of London." From the Geological Society.

"Dyas et Trias."

"Sur le Neocomien dans le Jura."

"American Geology."

"Notes pour servir à une Description Geologique des Montagnes Rocheuses."

"Reply to the Criticisms of J. D. Dana." From M. Jules Marcou.

Professor Tennant having taken the chair, the President read the following paper by the late Mr. John Brown, F.G.S., of Stanway :—

"On some Fossil Remains of Mammalia lately discovered in Essex; with Remarks on the Position of the Beds of Drift in that County, and in the County of Suffolk."

The subjects of the present paper are the Upper Tertiary beds which occur in the valley of the river Colne, near Colchester, and also those in the valley of the river Stour, at Ballingdon, both localities being in the county of Essex, and distant from each other about fifteen miles.

We will commence with the valley of the Colne. The right and left banks of this little river, for the greater part of its course, are composed of the common flint gravel of the district, and also of till, or boulder-clay. In December, 1857, while digging through this clay for the purpose of obtaining it for making bricks, five teeth of an elephant were discovered in a bed of black vegetable matter, or peat, about three feet thick, and two others were afterwards found in the same spot; but these latter had lost several of their plates, or laminæ. The right and left branches of the lower jaw of a rhinoceros, the left branch containing two molar teeth, *in situ*, and eighteen upper and lower jaw teeth were found at the same time, all in good preservation; and also portions of the ribs, bones belonging to the legs, and joints of the rhinoceros. Associated with these was a portion of a tusk of an elephant, three feet six inches in length, very deeply curved, its curvature being six and a-half inches deep from a chord line, two feet nine inches in length, and five inches in diameter at each end; it was probably the medial portion of a tusk.

In November last other remains of the elephant and rhinoceros were obtained from the same bed of peat. Those belonging to the rhinoceros were portions of the ribs, bones of the feet, end of a humerus, and the end of a femur. At the same time a larger portion of an elephant's tusk than the one found in 1857 was met with; this was five feet four and three-quarter inches in length from base to outer point, five and a-half inches in diameter at its larger end, and three and a-quarter inches near its outer point. This portion contained about one foot of its hollow base. Ten feet is not an unusual length for a fossil tusk of the elephant. I found one at Clacton, on the Essex coast some years ago, that was twelve feet long upon the outer curve. The portion lately found in the Colne valley has lost eighteen inches at its external point, and two feet of its hollow base; these added to the five feet four and three-quarter inches form a tusk nearly nine feet in length. According to our best authorities, a tusk of this kind would require a length of three feet of hollow base, at least, to accommodate the fastening necessary to secure so heavy a mass of solid ivory to the head of the creature.

The curvature of the two tusks from the peat of the Colne valley is remarkable, being much deeper than that of the tusks found on our coast and other parts of the county. Several of the latter, of the length of six and eight feet, have come under my notice, whose curvatures have formed segments not more than seven or eight inches deep, while the specimen from the Colne valley forms a curve fifteen inches deep from its chord line to the upper surface of the tusk. The uniformity in the curvature of the tusks, and their correspondence in diameter, and the fact of their being discovered in the same stratum, leave no doubt of their once crowning the head of the same elephant.

While discussing the subject of fossil tusks and other interesting remains of these extinct quadrupeds, I would draw attention to a discovery which was made about three years ago in the valley of the river Stour, at Ballingdon, fifteen miles north of the Colne valley. At Ballingdon bones and teeth of the rhinoceros, elephant, deer, horse, and ox have been discovered from time to time during the last thirty years. The most recent discovery of this kind was about three years ago, when a splendid tusk of an elephant, several teeth of that animal, a humerus of a rhinoceros, teeth of the horse and bones of the deer were found. The tusk was seven feet from the base to the outer point. It had lost three feet of its hollow base, and a small portion of its point, and it was seven inches in diameter at its larger end. This fine tusk is now exhibiting in the Sudbury Museum, the other fossils found at the same time are in the possession of the owner of the estate on which they were found. The Ballingdon tusk was curved in the same extraordinary manner as the tusks found in the Colne valley, but its curvature was still greater, the depth from the chord line being twenty-one inches, that is six inches deeper than the tusks found in the Colne valley. Whether this deeper curvature of the tusks of the elephant will constitute a different species or variety I must leave to be decided by those better acquainted with the subject than myself; but the difference between the two forms is very striking. Although, however, there is such a difference in the form of the tusks from the two localities above-named, there is a great similarity in the form of the teeth. These so nearly resemble each other in structure as to lead to the conclusion that the teeth from each locality belong to the same species of elephant, and perhaps to the species known as the mammoth. The fossil remains of the mammoth, it is well known, have been discovered in places widely separated geographically.

It was believed not long ago that the elephant's teeth found in the tertiary beds in England were of the same species with the Asiatic elephant, but on comparing them the difference appears very evident; and subsequent investigations have declared them distinct species.

The bones and teeth of the elephant and rhinoceros found in the Colne valley were, as I have observed, embedded far below the surface, in black peat, or vegetable matter, but those of the Stour valley were found in gravel of the coarsest kind, consisting of large flints detached from the chalk, fragments of granite, slate, large angular pieces of oolite, and sandstone. An interesting collection of most rocks in the geological series might be obtained from this gravel. Greenstone, porphyry, and basalt have also contributed very largely to this enormous mass of debris.

The junction of the chalk and boulder-clay is seen in all the pits and excavations here alluded to, forming a line dipping easily towards the south, jagged and broken by sandpipes and hollows. Ballingdon Hill, distant about a mile from the place where the Stour valley remains were found, possesses all the character of true till, or boulder-clay. Here may be seen many blocks and rounded masses of various rocks of the kinds before noticed, lying dispersed throughout its whole thickness from the junction of the chalk below to its summit, a depth of about eighty feet. The boulder-clay pursues a southerly direction for ten or twelve miles, to the Colne valley, which intersects it at the village of Chapple. Crossing this valley, it is met with again at Copford, but here it is much modified by drifting action. In the cuttings of the Stour Valley Railway, this deposit was much exposed, and many fossils were obtained, both secondary and tertiary, which will be presently noticed. Throughout the whole of this tract the boulder-clay preserves the same character, both lithological and organic, as we see in it at Ballingdon. It is in general unstratified, except on the upper part of hills and in other places where there are unmistakeable evidences of its being modified by drifting action in water, as in the valley of the river Colne.

The following fossils have been found in the boulder-clay of Ballingdon and of the Stour valley:—*Gryphæa dilatata*, *G. incurva*, *Ananchytes ovatus* (cast), *Vertebræ of Saurians*, *Plagiostoma spinosa*, *Ammonites dentatus*, *A. Lamberti*, *A. annularis*, *A. Bakeri*, *A. biplex*, *Pholadomya obtusa*, *Ventriculites*, *Terebratula Gibsii*, Serpulæ, Sponges.

From Ballingdon southward the chalk dips so as to hide its junction with the boulder-clay, which is immediately over it. Our present observations embrace a line of country of about twelve or thirteen miles in extent; and within this space, wherever this clay is exposed, large boulders and some angular fragments of stone are sure to be found, most of which have been removed from great distances.

The chalk appears to have been stripped off the surface to a very great extent in this district; we are guided to this conclusion by the existing patches of that rock occurring *in situ* at various places. In proceeding from Ballingdon in a northerly direction, we meet with no more chalk till we reach the little village of Boxted, seven or eight miles from Ballingdon, where may be seen a small patch or hillock of chalk, level with the surface, which is used for manuring land. On leaving this spot we see no more chalk till we arrive at Bury St. Edmunds, twelve miles distant, where it is used for lime. The same geological feature is observed between Bury St. Edmunds and Norwich. The chalk only appears occasionally until we reach the last named city, where it again comes to the surface.

The intervals between the chalk stations of Ballingdon, Boxted, and Bury St. Edmunds are occupied by boulder-clay, covered by a rich soil. In these intervals the fossils of the boulder-clay are frequently turned up by the plough, and in the process of draining the land. The following have been found, viz., *Ammonites rotundatus*, Hartest; *Phaladomya obtusa*, Whipstead; *Gryphæa dilatata*, Whipstead; Sharks' teeth, Harringer. I have observed that wherever Ammonites, Belemnites, and Gryphæa are found in the surface soil, the boulder-clay is not far from the spot. The same phenomena are seen here as in Suffolk.

It appears to have been in the intervals between the remaining portion of chalk *in situ* at Ballingdon, Boxted, and Bury St. Edmunds that the moving power put forth its greatest energies, when breaking up and sweeping away the solid chalk, and filling up the intervals with boulder-clay. It would be very interesting to know at what depth from the surface this great moving power—water, has acted upon the chalk in this district, grinding it down and liberating its fossils and its flints, and depositing them in the large masses which have been just noticed.

The different beds beneath the Colne valley, taken in descending order, consist of vegetable soil, modified boulder-clay, peat, flint-gravel, and London clay. The strata were measured at the time of the discovery of the teeth and bones of the elephant and rhinoceros already mentioned. The bed of peat in which these lay is about three feet thick, and formed the upper surface in a depression of gravel. This gravel is about seven feet in thickness. The peat is composed chiefly of vegetable matter, in which are numerous seed-vessels and leaves of moss, and remains of insects in bad condition. For this information I am indebted to the kindness of my friend, Professor Henslow.

The gravel which supports this bed of peat, is composed chiefly of flints much broken, and embedded in reddish sand. In it we do not observe any of the boulders which we find so abundant at other places in the till. Its thickness, as just stated, is about seven feet.

Immediately over this bed of gravel and peat, there lies a deposit of modified boulder-clay, forty-seven feet in thickness, in horizóntal lines of stratification, and free from boulders, or pebbles. Vast quantities of bricks and pipes for draining land are made of it. Organic remains have not been met with in the modified till of the Colne valley; while at the Copford brickfield, where this clay has been extensively wrought, Gryphæa, Belemnites, Ammonites, various forms of Foraminifera, and remains of elephants have been collected.

A bed of alluvium, from three to four feet thick, completes the section of the Colne valley, a section which is interesting, not only on account of the fossils—the records of times long past—but as establishing the priority of deposition of the red gravel over that of the till, or boulder-clay. This order of superposition of the boulder-clay over the red gravel is repeated in two other localities in this county, viz., in a brickfield near Kelvedon, and in a gravel pit near Thaxted; there is also the same superposition at Muswell Hill, near Highgate.

On the left bank of the river Stour, as we ascend the stream, and between the towns of Bures and Ballingdon, and in the parish of Lamarsh, may be seen seven or eight blocks of greensand, of various sizes, all of which are angular, and the largest of which weighs about a ton. These are lying by the road side, and appear to have been brought from Petersfield, in Hampshire.

On examining the texture of the stone, the particles of greensand which give the name to the formation from whence they come, occur in groups and patches, like the greensand rocks at Petersfield; and the appearance of the stone is unlike that of the greensand generally, in which the particles are distributed more regularly throughout the mass.

In this district, and over all the eastern counties, blocks of various kinds of stone are met with in the boulder-clay, which we often see detached and lying on the surface. Many of them are from great distances, and of considerable weight, as much as a couple of tons. They are of various kinds, Derbyshire marble, Hastings sand, Druid sandstone, calcareous grit from Oxfordshire, porphyry, basalt, granite, syenite from Leicestershire, etc.

A collector who has visited the parent rocks *in situ*, will readily recognize, with feelings of great satisfaction, the portions of rocks which he had previously known in their native places.

Although many detached blocks of stone are to be seen lying on the surface in the eastern counties in various situations, having corners and sharp ridges upon them, still, at the same time, there are other blocks, extremely hard, which are rounded, smoothed, and polished.

Nearly all the instances upon record of the remains of large extinct quadrupeds being discovered in Europe, especially in Britain, have occured in beds of flint gravel, and in what was formerly called diluvium; and such discoveries have been often repeated in our own country, as in the two recent occasions above stated, in the Colne and Stour districts.

It has been recorded by the late Dr. Buckland, that in more than forty different places in Britain the fossil remains of the elephant, rhinoceros, hyæna, and many other extinct quadrupeds have been discovered either in gravel or in boulder-clay.

The great operations of nature which produced our beds of detritus, and the fate which attended the animals whose fossil remains we have just now contemplated, appear closely related. Are we then warranted in concluding that the cause, whatever that cause might have been, which formed the great beds of detritus, determined the fate of the quadrupeds at the same period?

We learn, from high authority, that a specific difference exists between the teeth of the fossil and recent elephant; and a difference of structure may be seen in the specimens before the meeting.

Many other instances might have been noticed, where the fossil remains of animals, extinct in our latitude at this period, have been discovered from time to time, for some years past, in these comparatively recent beds.

We have not made any remark on the freshwater productions, which have yielded abundant remains of the elephant, rhinoceros, hyæna, lion, deer, ox, etc.; as our principal object was directed to the deposition of the detritus of the eastern part of Essex.

The above paper was illustrated by numerous drawings. Several of the fossil remains, above alluded to, were also exhibited.

A discussion followed, in which the President, Prof. Tennant, Mr. Charlesworth, Mr. Cresy, and Mr. Cumming took part; and it was resolved that, as a mark of respect to the author, the paper should be printed at length in the Proceedings of the Association.

Ordinary Meeting, 6th Feb., 1860.

The Rev. Thos. Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association: H. S. Bower, Esq.; Alfred Grugeon, Esq.; Cecil Gurdon Moore, Esq,; and John Wright, Esq.

The following donations were announced:—

"The Abstract of Proceedings of the Geological Society of London." From the Geological Society.

A Collection of Lower Oolite Fossils from the neighbourhood of Sherborne. By J. W. Butler, Esq.

Greensand Fossils from a Phosphate of Lime bed, near Ashwell, in Hertfordshire. By S. Crawshay, Esq.

The following paper was read:—"On the Theory of a Gradual Withdrawal of Heat from the Earth as Explanatory of Certain Geological Phenomena." By J. Curry, Esq.

The author commenced by stating, that if just views of the various stages of the earth's development be sought for, it is necessary both to bear in mind the various proportions of gaseous, liquid, and solid matter at the different periods, and also to remember that the past and present conditions not being identical, it is not always safe to argue from the analogy of existing phenomena.

He then proceeded to describe the probable events happening in the interval between the formation of the granitic rocks and the deposition of the old red sandstone, such as the gradual cooling of granite originally in a plastic state, and the conversion into water of a vast mass of superincumbent matter, which had at first been of a mixed aërial and aqueous character. The varying relative levels of land and sea at certain epochs were attributed more to a fluctuating ocean than to elevations and depressions of the solid shell of the earth. This crust in the Silurian period was asserted to be of such a thickness and strength as to produce a general and permanent stability: the land was also of a riverless character.

At the commencement of the Carboniferous era the ocean was supposed to have decreased, and the areas of dry land to have increased, producing extended shore-lines and an augmented flora. Thc Carboniferous system was represented as notable for its trap rock, and for occupying a position on the flanks of elevations favourable for the egress from the interior of molten fluid. The determination of internal heat towards the south-eastern submerged areas of the British Isles, and its effects on the fissures and on the deposition of sediment were noticed. Taking the Pennine chain as the eastern or south-eastern flank of the Cumbrian uplift, the author cited as illustrations of the flow of heated matter from the interior at different eras, the granites in the lake districts, the granitic porphyry of Dufton Pike, the Teesdale basalt, the basalt in the Wear valley, near Stanhope, and the trap-dykes from the vicinity of Middleton, in Teesdale. The reasons for an ultra-tropical climate at the commencement of the mountain-limestone formation, and the causes to which the richness of the lead mining district of the north of England was due, were pointed out; the conditions of mineral veins, faults, &c., were laid down; and suggestions made respecting the contortions of strata, throw of mineral veins, and their mineralization. The effects which the supposed alterations of level of the ocean produced on the vegetation at the close of the mountain-limestone period were remarked.

The coal period was stated to be one of surpassing interest. The atmosphere, abounding in moisture, carbonic acid, and heat suitable for vegetative life, nourished, in this era, a profuse sea-marginal flora. The vegetation being repeatedly uprooted and successively transported (generally to the south and south-east in the region of the British Isles), was submerged in basin-shaped repositories, and being covered up by sediments, and subjected to a considerable warmth, was converted into beds of coal. The sources from whence the carbonaceous matter in the principal coal-fields was derived were separately sketched.

The conditions previously laid down, namely, a large ocean, its oscillations during its decrease, and the general stability of the land, were applied to solve the phenomena of the northern drift. The author concluded by describing the routes of the detritus from the

Lake district, and of the granite from Shap Fell, &c., with a few additional remarks on the theory he had advanced.

Ordinary Meeting, 5th March, 1860.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following were elected members of the Association:—Miss S. G. Tripp; Lieut. J. Barugh; Joseph N. Dalton, Esq.; Rev. John Williamson.

The following donations were announced:—

"The Geologist" magazine for March, 1860, and a Diagram of some of the principal Flint Implements found in the Drift. By S. J. Mackie, Esq., F.G.S.

"The Abstract of the Proceedings of the Geological Society of London." By the Geological Society.

The following papers were read:

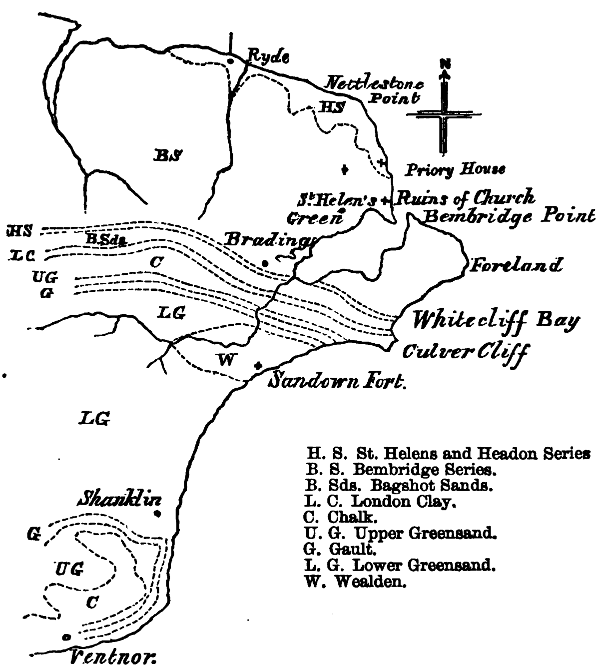
1.—Notes on the Geology of White Cliff Bay, Isle of Wight. By Mark Norman, Esq.

White Cliff Bay is situated about four miles to the north-east of Sandown, being reached after passing the fort, by a path at first skirting the edge of the cliffs, and then crossing over the high land called Bembridge Down, near the monument on its summit.

The beds of the Wealden, Lower Greensand, Gault, Upper Greensand, and Lower Chalk, gradually rise in height until we reach the White Chalk of Culver Cliffs, where, at Hermit's Hole they attain an altitude of something like 300 feet. All the strata of the above-mentioned deposits partake of the disturbances caused by the rise of the Wealden.

The magnificent chalk cliffs of Culver, says Dr. Mantell, in his "Geological Excursions," can only be seen to advantage from the sea. The dip of the beds is seventy degrees to the north, and is easily defined, even from a distance, by the layers of flints.

Pursuing our walk in an easterly direction, the flat undulatory Tertiaries that constitute the country around Ryde, St. Helens, and Bembridge, gradually come into view, together with the little bay of Whitecliff, with its many cliffs of coloured clays and sands lying far below. These latter terminate in the foreland, the rocks of which, at low water, can be traced some distance out to sea; and, at the extremity of which is the light ship. In the distance can be seen distinctly the shipping at Spithead, while beyond them is the Sussex



coast, trending away to the eastward until it is lost in a faint blue line, comprising Selsea Bill, Bracklesham Bay, Emsworth, Chichester, Pagham, &c., backed by the splendid chain of chalk hills, and the far famed South Downs. Following the descent of the Culver Cliff, we come at last upon a narrow foot-path; if we follow its windings we find ourselves in a small gorge or valley, overgrown on the left, or tertiary side, with a tangled mass of briars, stunted oaks, brambles, and thorns, intermixed with weeds and rank grass. On the other side are large walls of white chalk, with the flints exposed. The strata have been upheaved from a horizontal to a vertical position; and, in consequence, the beds of chalk are, in some places, almost on end. Many of the flints are also crushed to an impalpable powder. This disturbance can be traced across the whole length of the island by any one who chooses to examine the different chalk pits at Brading Down, Newport, Carisbrook, and Calbourn. At these places, the chalk will be found to be rent into fragments, and the flints more or less crushed. Following the sinuosities of the footpath, we come upon a small well, the only water to be had in the neighbourhood. At last we arrive at the shore, amidst boulders of white chalk, flints, and masses of mottled clays (Woolwich series,) in profusion; this is the south-west end of the Bay, and the junction of the chalk with the tertiaries. The *Belemnitella mucronata* may here be found in the cliff on the right hand; also *Ananchytes ovatus*, and *Galerites albo-galerus*. I have never been able to obtain any other species of white chalk fossils at this spot, if I except fish remains, in detached scales.

Turning to the left, the mottled clays of the Woolwich series are passed; they contain no organic remains. In the year 1847, Dr. Mantell stated the Ditrupa bed to have been between the Woolwich and the Bognor series, or, to use his own words, "about forty-five or fifty paces from the chalk;" but some few years later a slip of the clays took place, and completely covered up the Ditrupa bed; so that geologists came and went, but could never discover this far famed bed. Having been myself several times disappointed, I determined on my last visit to find this stratum, if possible. I paced the distance as directed, and then mounted over the clay, towards the crumbling cliff in the back ground, when after scrambling about amongst the weeds and long grasses, I discovered a large outlyer of about ten feet long, of a reddish brown colour, composed of clay and sand aggregated together, in which was a layer of rounded pebbles, amongst which I discovered the *Ditrupa* in masses, but very small and very friable, the shells being reduced to a white powder. Many pieces, however, which I broke off, contained specimens sufficiently perfect to determine the species, but that was all. There were associated with the *Ditrupa* some small shark's teeth, which were all the organic remains it contained, as far as I could discover. The next beds in succession are the Bognor series; in the lower portion of which, all the fossils I could find were a few large *Panopœa.* Professor Forbes states the *Panopœa intermedia* is associated with *Pholodomya margaritacea,* but I found none of the latter; and the outlyer containing the Ditrupa was below, instead of above the "Panopœa bed." Probably Mr. Gibbs found the former *in situ*; see page 33 of the late Professor Forbes' work on the tertiary fluvio-marine formations of the Isle of Wight.

The Ditrupa is only fit for comparison, and not for the cabinet, as the shells can be obtained in a better state of preservation at Alum Bay, and, I believe, at Barton also. Here I would observe, that it is not my intention to enter into any scientific disquisition respecting the comparative equivalents of the strata, or fossils of White Cliff Bay with other places, but merely to state my own experience of the locality. Those persons who wish to see the subject well discussed and worked out in detail, I would refer to the book above-mentioned. In point of interest, White Cliff Bay is not to be compared with Alum Bay; still the geologist would find a day well spent in the examination of the strata. As to the fossils, with the exception of some fine specimens of *Venericardia planicosta,* associated with *Turritellæ,* there are but few fit for the cabinet. Going eastward, a small cliff of yellow sands present themselves, quite unfossiliferous, which are said to be the equivalents of the coloured sands of Alum Bay. At the end of these, or rather what was once their base, is a vertical band of flint pebbles, about four inches thick; next a bed of *Venericardia,* a little larger than the common cockle, associated with a small species of *Turritella,* the equivalents of the Bracklesham series on the opposite coast. Small bands of fossils succeed each other, until we come to the main or principal beds, denominated the London clay series, all in a vertical position, the lowermost portion of which contains a band of very large *Venericardia planicosta.* Then comes a mass of fossils embedded in clay and sand, a good deal permeated with iron, and ranging from three to four feet in thickness, the middle portion containing *Voluta, Turritella,* in the upper part of which is a bed of *Nummulites,* varying in size from that of a fourpenny-piece to a shilling. All these shells are embedded in a mass of mud, that when disturbed *in situ*, emits a most disagreeable odour; these remains, especially the Volutes, although so numerous, are extremely brittle, and squeezed out of shape. They are almost untransportable, except in blocks, into which the mud can be cut, and left to dry. With the exception of the large *Cardium* and the *Nummulites*, they afford poor specimens; still, with great care, the collector may manage to take home a few examples of the *Turritella*; which, to clear from the matrix, requires a large needle and much patience. Sharks' teeth and rolled decayed bones of fish are also found in this ancient grave-yard, where lie millions of the inhabitants of a world gone by.

It will be seen, that the fossils of the London clay of this locality, although interesting to view, *in situ*, are not fit for typical specimens of those deposits; and the student will obtain the like species from Barton and Hordwell, where the shells are as perfect as in the present seas.

We will now travel northward, towards the foreland. The only sign of fossils is to be seen in a little gully, some three or four hundred yards from the London clay beds, where they are contained in a hard compact limestone, and are, consequently, very difficult to extract whole; but some well known forms of Barton shells, such as a *Dentalium*, several species of *Fusus*, *Crassatella*, *Cytherea*, *Nucula*, *Turritella*, etc., may be observed a little further eastward. Near the top of the cliff, I found some detached blocks of marl, containing a small species of *Natica*.

We now come upon the beds of Limestone, termed by the late Professor Forbes the Bembridge series, in contradistinction to those of Headon Hill, which limestones were always considered to be the equivalents of the Headon series, until the publication of his papers on this series of deposits. For the details of the strata, of which I am now giving but a passing sketch, I would again refer the reader to the work by the late Professor Forbes; he will there see that instead of those limestones at Bembridge Point being the equivalents of those of the Headon series, they belong to an independent section, and occupy a superior position; and that those of Hempstead are also again above these, as well as their equivalents at Parkhurst; the two latter being the highest series of Tertiaries in England, and resting upon the Bembridge limestone.

In the fallen blocks of limestone on the shore towards the Point, are to be seen plenty of the *Limnœa* and *Planorbis*, but all in a bad state of preservation, existing only in casts. Any attempt to clean them of the matrix ends in disappointment. The only perfect remains are those little seed-vessels of an extinct species of *Chara*, which, to be detected, must be viewed with a good pocket lens. At the Point, in weathered beds of marly limestone, are ledges formed by the clays and limestones proper, leaving the fossils exposed. It is interesting to notice the changes which must have taken place in the course of time on only about some twelve to twenty feet of the strata out of a series of a hundred and fifteen feet: first brackish water, next marine beds, with a layer of oysters in their midst, next pure fresh water limestone, with river-snails and vegetable-seeds, ten or twelve feet thick, succeeded again by a few brackish-water- and river-snails intermixed, and again, by river or lake shells, such as *Limnœa* and *Paludina*; and again by a thick bed of limestone of fresh water origin, terminating in a bed of marl, containing also the *Limnœa* and *Planorbis*.

The fossils themselves, with the exception of the pretty little oyster, all exist in the form of casts. There are bivalves and two or three varieties of *Cyrena*, with the smallest possible indication of shell remaining; they live in bands, and appear to have been all destroyed by some sudden catastrophe, as they have both valves entire and close shut; and, apparently, died where they had lived, in beds like those of the oysters. Amongst the oysters there is one little shell, the cast of which is well preserved: it is a species of *Fusus*, and the hard casts exhibit the sculpturing on the outside as perfect and as fresh as during life; specimens of the *Cerithium*, also lie in beds as thick as pins in a cushion, but completely denuded of their beautiful ornamental shell; all that can be traced of them, are the casts of the inner whorls, taken in the mud they were embedded in; nothing remains of the original but its skeleton. Mr. Bristow's section gives *Chara*, *Paludina*, *Limnœa*, *Planorbis*, *Cyrena*, *Melania*, etc. But, as I have before observed, none are good typical specimens, excepting the *Chara* and a few of the *Planorbis*. I have seen tons of the Bembridge limestone broken up for building purposes, and in the whole could not detect a fossil worth carrying.

But we must travel on round the point. When the tide is out, there will be seen bands of marl, containing casts of *Cyrena*, etc., and clays and sands with bands of bivalve-shells much decomposed. A cliff composed of red clay and flint boulders stretches away to the harbour, where it is separated by a sandy down and a small arm of the sea from St. Helens. Along the shore, between the Point and the Harbour, are scattered blocks of Bembridge limestone, full of the ever present *Limnæa.* The flints here, which are washed out of the cliffs, are highly interesting, and much resemble those to the east of Ventnor; and are, no doubt, the greater part, the ruins of an extensive chalk formation. Some good specimens of *Echinidæ*, *Terebratulæ*, and sponges of exactly the same description as those found at Ventnor, are contained in the flint boulders. The flints also yield some excellent specimens of mineralized sponges for polishing, such as *Choanites*, *Ventriculites*, *Siphoniæ*. I once found here a specimen of *Choanite*, measuring five inches by three and a half.

We are now at Bembridge Point; crossing the harbour by the ferry, we come to a white tower, which is all that remains of an ancient church, deserted, no doubt, and left to its fate, on account of the steady but sure encroachment of the sea, through the sinking of the land; a sinking which has probably caused the formation of Brading Harbour. According to Mr. Godwin-Austen's researches, there is but about seven feet fall for the fresh water over the sluice from Sandown marshes into the harbour; and, according to the same high authority, all the land from Dunnose, near Bonchurch to beyond Brighton, including the site of Portsmouth, and all the towns up the south coast, together with hundreds of acres of land, composed chiefly of the Tertiaries, are sinking. If the depression still goes on, of which there is ample evidence from the remains of submerged trees and plants, and also of sea-shores and bottoms, cut through at Portsmouth for the construction of docks, there is no doubt, unless the encroachments of the waves can be arrested, as in Holland, that every town on the coast, must, in time, share the fate of the old city of Selsea, as related by Camden, the historian.

According to the statements of Mr. Austen, he has succeeded in tracing the "Elephant-bed" of Dr. Mantell at Rottingdean, along the coast and across the country to the gravel cliffs of the Bembridge foreland, but from the distance and the amount of time required to examine the drift capping of the cliff, I have never been able to observe this.

Continuing our journey beyond the deserted tower, we come to Nettlestone and St. Helen's Point. The loose blocks of limestone along the shore are unproductive of good specimens, containing only imperfect casts of *Limnæa*, *Helix*, and *Planorbis*. It was in the low cliffs of this locality, that the carapace of a fossil turtle, sixteen inches long and nine wide, was discovered by a man engaged in extracting stone for building purposes. An extended account of the fossil, will be found in Mantell's "Geological Excursions."

I have endeavoured to find in this part the equivalent of the Binstead, Seafield, and Sconce "Bulimus band," but have hitherto been unsuccessful. Possibly its outcrop does not arise between Seafield and Bembridge Point, on account of the extreme thickness of the Bembridge limestone, and the undulations of that formation. The Bembridge series is wanting in several characteristic fossils which are exhibited at Sconce, such as *Bulimus ellipticus*, and the large *Helix globosa*.

On the shore towards Nettlestone Priory, is a sloping bank composed of layers of black muddy clay, containing two or three varieties of *Cerithium*, *Melania*, *Cyrena*, etc. Beyond, at an opening in the bay, is a low hill composed of clays and sands, in which the fossils can be traced in seams exposed to view by the crumbling of the cliff. The two uppermost bands are the most interesting, being composed of a stiff bluish clay, very brittle, and much resembling gault in appearance and texture; the uppermost band is full of the half valves of the *Cyrena pulchra*, whilst the lower contains the *Cyrena semistriata* in abundance; both bands possess few other fossils, with the exception of *Cerithium* and *Melania*.

The shells in Priory Bay are very badly preserved, and extremely brittle. The clays are so laminated and so permeated by water, that the labour of collecting a few tolerable specimens becomes a very difficult task.

As very little mention is made of this locality, either by Mr. Austen or Mr. Bristow, in the work so often referred to, perhaps it has not been thought of sufficient importance to demand a special notice. Probably equivalents of the same bed would be found in many places in the long distance between here and Hempstead. Be this as it may, I am fully convinced that if the locality were well and properly examined, it would yield many additional specimens of fossils. The beds are, no doubt, in close proximity to the Bembridge marls, and, although small in extent, are highly interesting. The collector will have but little difficulty in finding the place, which is about fifty yards to the westward of the steps leading from the shore to the Priory house, about a mile from Sea View, and, probably, four miles from Ryde.

2.—On a Stalactite found in Flagstone Rock, near Haslingden. By the Rev. L. H. Mordacque.

In the spring of 1859, one of the quarrymen of our district discovered a stalactite in a flagstone cutting, about half a mile from Haslingden, a manufacturing town in the east of Lancashire, between seven and eight hundred feet above the level of the sea. The man brought it to me for inspection; but it was so totally different from the usual stalactite and stalagmite of Clapham Cave, in Ingleborough —so much more vitreous and polished, that I felt suspicious that a mistake had been made, and that he had found the "pipe," as he called it, under circumstances somewhat different from what he imagined them to be. However, some time after, the quarry was visited by a friend and myself, and we noticed, some twenty yards below the surface, or "feigh," as it is termed here, a thin layer of rock, some few inches thick, different from that which rests upon it, and from that also over which it lies. On examining this more carefully we found a layer of gypsum, in many places exhibiting fine crystals. This seam may account for the stalactite in question; the water above percolating, and washing down particles of lime tinged with iron, into the fissures of the rock below, and gradually forming stalactites, such as the one in my possession.

A portion of the above-mentioned stalactite was exhibited.

A discussion followed the reading of the papers, in which the President, Professor Tennant, Mr. Cresy, Mr. Cumming, and other members took part.

A bone, supposed to be that of the Irish Elk, which had been found at Deptford, in the gravel, during the progress of the excavations now being made for the purposes of the metropolitan main drainage, was exhibited. Professor Tennant mentioned that in cuttings which had been made for the same purpose at Dulwich, impressions of leaves had been found in the London clay. Mr. Cumming also stated that similar impressions are to be met with in the brick pits at Loam Pit Hill, near Lewisham.

The President announced that the Committee were desirous that occasional excursions should be made by the Society to places of geological interest; and that Professor Tennant had kindly volunteered to lend his aid in conducting such field-lectures.

In accordance with the above intimation of the President, a large number of the members visited Folkestone on Monday, the 9th of April. The party, which was under the guidance of the President, Professor Tennant, and others, availed themselves of the facilities afforded by the Directors of the South Eastern Railway Company, and left London by the excursion train at 8·35 a.m., arriving at Folkestone soon after 12 o'clock. They proceeded at once to the shore, and spent several hours in examining the chalk, greensand, and gault, as exhibited in Eastwear Bay, the Warren, and Copt Point, and procured several specimens of the characteristic fossils. A pamphlet by Mr. Mackie on the geology of the district, which had been reprinted from the pages of the "Geologist" magazine, by the kind permission of the editor, and which had been distributed to the members, furnished a useful guide for such as were strangers to the locality. The party returned to London the same evening.

It is intended that another excursion should be made in the course of the summer (probably to Maidstone, in Kent, on the 19th of June), of which, however, due notice will be forwarded to the members.

*** It is requested that those members who are desirous of exchanging fossils will inform the Secretary from what strata they can supply specimens, and from what formation they would wish for others in return. The Secretary will then, as soon as possible, endeavour to place the members desiring to exchange in communication with one another.

The Committee trust that those members who have the opportunity of making geological investigations will favour the Association with papers. It is desirable that as early an intimation as may be should be given to the Secretary of the subjects of such papers, and of the time when it is intended they should be read.

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

No. 5.] [Session 1859-60.

Ordinary Meeting, April 2nd, 1860.

The Rev. T. Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—The Rev. Edward Myers, and W. Compton, Esq.

The following donations were announced:—

A specimen of Ironstone from Leicestershire. By W. T. Rickard, Esq., F.G.S.

"The Geologist" Magazine for April. By S. J. Mackie Esq., F.G.S.

"The Abstract of the Proceedings of the Geological Society of London." By the Geological Society.

Mr. Charlesworth, F.G.S., read a paper on "The Crag."

An abstract of this paper will be printed in the next number of the "Proceedings."

Some specimens of impressions of leaves from the London Clay at Dulwich were exhibited by Mr. Bott; and Mr. Evans exhibited similar impressions from Loam Pit Hill, Lewisham.

Mr. Rickard also exhibited some rich specimens of lead ore.

Ordinary Meeting, May 7th, 1860.

The Rev. T. Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—Dr. C. T. Richardson, and H. J. Sanders, Esq.

The President announced that the Committee had come to the resolution of conducting an excursion to Maidstone on the 19th of June.

The following donations were announced:—

A stereoscopic photograph of fossil human bones found at Le Puy, Haut Loire, France. By H. Deane, Esq.

It was resolved that the thanks of the Association be given to Mr. Deane for his donation.

The President announced that a member of the Committee had kindly offered to take stereoscopic photographs of remarkable fossils, for the purpose of distribution among the members at the expense of the Association.

The following paper was read:—

"On the Action of Heat on certain Sandstones of Yorkshire." By C. Tomlinson, Esq.

In passing along the highways of a country, the geologist can generally tell at a glance what is the mineral character of the district in the kind of metal employed to mend the roads; whether there are iron or other works in the neighbourhood, the slags of which are applied to the same purpose, or whether the traffic is so great, and the neighbourhood so poor in road-making material, as to necessitate the importation of road metal from a distance. Where stone abounds, the picturesque hedgerows are often superseded by stone walls, and where the stone is of lamellar structure and plentiful, it is used to pave the footpaths between distant villages for miles together.

In rambling among the Yorkshire villages in the neighbourhood of Huddersfield, in September, 1859, the abundance of stone was apparent in the boundary walls and paved footpaths of the district, and there was nothing to excite remark, until, approaching a village called Almondbury, I was struck with the brick red appearance of the roads, which increased on that side of the village nearest Huddersfield. I had no means of accounting for this appearance, for there was no stone in the neighbourhood of that tint, nor any works the secondary products of which at all resembled it. A slight shower of rain brought out the colour more vividly, and it appeared still more to deepen in a bye-road leading out of the main road. Pursuing the bye-road for a short distance, I found myself in a quarry of several hundred feet in length, and what was my astonishment to notice on its vertical walls extensive marks of the action of fire, such as large red patches, brown and purple masses, blisters, and incipient vitrifications; and these signs appeared at intervals, rising from the floor of the quarry to a height of forty or fifty feet. Seeing some men at work at the further end of the quarry, I went up to them, and found them underminining what appeared to be a portion of the quarry in a highly vitrified state. I then learnt from them the cause of these extraordinary phenomena, and was able to explain the red appearance which had excited my attention in the road.

The stone of the neighbourhood not furnishing a very durable road-metal in its natural condition, it has long been the custom to harden it by the action of fire, for which purpose a stone stack is constructed in this quarry two or three times a year, the inferior kinds of stone, and the refuse after the building stone has been got out, being used for the purpose. For the construction of this stack, an area of about sixty feet square is laid out in such a manner that the face of the quarry may furnish one, if not two, vertical sides to the stack, for the sake of shelter. On the present occasion the stack had been constructed at the end of the quarry, so that two vertical walls were thus obtained for its support and shelter. The stack is commenced by spreading a layer of broken stone over the base; upon this a layer of coals, that fuel being very cheap (a coal-pit being within sight), then another and thicker layer of broken stone, care, however, being taken to form suitable channels for the entrance of air, and in this way, with three layers of coal and five layers of stone, a stack is built up to the height of fifty feet and upwards. The fuel is then kindled at the ventilating openings, and the draught being properly regulated, the combustion quickly spreads, and continues for about three months, varying with the state of the weather, and producing at night a red glow in the sky visible for miles around. As the fuel burns out, the stack diminishes in height, and is left for a couple of months or so to cool. The men then proceed to break it up by means of long crow-bars and picks. This is no easy task, since the mass is very hard, and has the appearance of volcanic slag or scoriæ. The men, however, somewhat abridge their labour by commencing at the base of the stack, driving in their crow-bars, and undermining a considerable portion, until huge fragments of many tons weight crack and fall off. The workmen judge by the cracking sounds as to the proper time for retiring, and they sometimes assist the disruption by pouring water into the crevices above, if the rain does not do it for them. The cold water coming in contact with the vitrified mass, which, from its low conducting power, cools very slowly, produces large cracks, which assist in its mechanical disintegration. The large masses are broken up by means of sledge-hammers into smaller masses, and these are again broken with smaller hammers into pieces about the size of a hen's egg, for placing on the roads. I collected a number of fragments from the stack which I have now the pleasure of laying before the meeting. It will be seen that they are all more or less vitrified, sonorous, and brittle, and one or two of the specimens have the appearance of a rude kind of pottery or stone-ware; the material is probably a crude silicate of alumina and iron.

Observing on the face of the stack which had been exposed to the weather a considerable amount of efflorescence, a portion of which being placed on the tongue, instantly melted with the cool sensation produced by an alkaline salt. The workmen informed me that the stack was a capital guide to the weather, as they always knew of the approach of rain many hours, and even days, before, by the change in its appearance.

On mentioning the above particulars to friends in the neighbourhood, I was surprised to find that the information was as new to them as it was to me. They had, indeed, observed the red glow in the sky on winter nights, but were satisfied with the general information that it proceeded from some iron or other works, and had inquired no further. On referring to books descriptive of Yorkshire, including Phillips's well-known work, and Mr. Hobkirk's recently published "History and Natural History of Huddersfield and the Neighbourhood," which contains a chapter headed "Geological," I could find no mention of the circumstance. As an old man in the quarry informed me that the plan was in operation when he was a boy, and that his father spoke about it as a thing of course known in that place, and in one or two other parts of Yorkshire, where they had the right sort of stone, or "stone with plenty of fat in it," I was induced to refer to that old but admirable authority, Camden, in whose interesting folio I did not find what I sought, but met with information which led me to a result of so curious a character that, although it is antiquarian rather than geological, I trust the meeting will excuse me if I take the liberty of submitting it to them.

Camden says, "Six miles from Halifax, not far from the right side of the river Calder, and near Almondbury, a little village, there is a very steep hill, only accessible by one way from the plain, where the marks of an old rampire and some ruins of a wall and of a castle well guarded with a triple fortification are plainly visible." He then goes on to say that these are really the remains of the *Cambodunum* of the Romans; that in early Saxon history there was a royal seat here, and a cathedral built by Paulinus, the apostle of these parts, and dedicated to St. Alban, whence the village of *Albanbury*, now called *Almondbury*. "But," continues Camden, "in those cruel wars that Ceadwall, the Britain, and Penda, the Mercian, made upon Edwin, the prince of these territories, it was burnt down, which in some measure appears in the colour of the stones to this day."

The event here recorded by Camden took place in the eighth or ninth century. Eight centuries had elapsed before Camden wrote his description, and yet the marks of fire remained unobliterated during that long period. No cause, as far as I knew, had intervened since Camden's time to obliterate those marks of fire, why should they not therefore still be visible? "For this simple reason," was the reply, "that the whole of the ruin has long since been cleared away to make room for a public-house and tea-gardens, where our Yorkshire bands are fond of assembling for practice, and where parties of pleasure go to listen to them."

"That is not a sufficient reason," I rejoined. "Stone is so abundant in this district, that no one would think of carrying it from the top of the hill to the valley below, still less of carrying it below upwards, where the ruin would furnish abundant material for constructing the musical hostelry, and I dare say enclosing it in a stone fence; and in addition to all this I have no doubt there is plenty of stone scattered about, bearing the marks of the Mercian fire to this day."

It was therefore agreed that we should ascend the Castle Hill next day; but as I did not expect to find marks of fire so decided as on the stone of the stack in the quarry, but only the effects of a moderate heat, such as the higher oxidation of the iron, producing the well known reddish tint, I placed a piece of ordinary micaceous sandstone of the neighbourhood in the fire for an hour or two, and beg to call the attention of the members to the two specimens, when it will be seen at once which of the two has been acted on by the fire.

The next day we climbed the hill, and had no sooner arrived at the wall which surrounds the grounds of the public-house, than we were struck with the red appearance of many of the stones of which it is built, and which left no doubt that although a thousand years had elapsed since "Ceadwall the Britain and Penda the Mercian" in those cruel wars burnt down the castle and cathedral of St. Alban, there was still before us evidence of the fact, rendered if possible still more striking on breaking open some of the stones, where the action of the fire had in some cases penetrated only a short distance, and in others completely through, presenting to the eye the reddish tint as bright and fresh as that on the piece of stone which I had passed through the fire on the preceding night.

There are six specimens of stone from the Castle Hill now on the table, which I leave for the inspection of the members, with many apologies for having thus far intruded on their time.

A discussion followed, in which the President, Professor Tennant, Mr. Cresy, and others took part.

Specimens of London Clay fossils, which had been collected from the excavations now being made for the purpose of the main drainage at Kentish Town, were exhibited by Mr. Pickering.

Mr. Atkinson exhibited a striated specimen of chalk, found in the neighbourhood of Rochester, at a depth of eighty feet below the surface, which had the appearance of a tusk. Professor Tennant thought that its peculiar appearance was due to the same cause as that which produces slickensides.

Ordinary Meeting, June 4th, 1860.

Professor Tennant, F.G.S., Vice-President, in the Chair.

The following gentlemen were elected members of the Association:—The Rev. James Stanley Perceval; Walter H. Bartlett, Esq.; Thomas Brain, Esq.; Lieut. F. W. Hutton; Benjamin Pollard, Esq.

A donation of fossil bones from the Inferior Oolite at Sherborne, by J. W. Butler, Esq., was announced.

The following paper was read:—

"On the Flint Implements lately found in the Drift." By S. J. Mackie, Esq., F.G.S.

The author first pointed out the evidences that the fossil flint-implements had been actually worked by the hand of man, and alluded to the uniform characteristics observable in the manner in which the flints have been trimmed wherever they have been found. This trimming is peculiar and very evident in the undulating lines of fracture of the chips split off, always running from the outer edge towards the centre of the object. Such a constant method could not be imitated by Nature in the natural breakage of stones and pebbles by collision with each other, for the blows in such cases would be various in their directions, and not uniform. He then dwelt upon the point that they are really fossil, or belonging to a true geological age, giving details of the sections at Abbeville, Hoxne, and other places in which the superposition of the Drift-beds was known, and in which the particular layers from which the flint-implements had been met with had been authenticated.

The author then exhibited specimens of the various kinds of worked flints which had been extracted from the gravel and Drift-beds, such as flake arrow-heads, flake knives, the little perforated sponges, probably used as beads, and the great pointed flints hitherto commonly called "celts;" but to the continued use of which term the author offered objections, pointing out that a "celt" is radically different in form, being worked sharp at the broad end, and blunt at the pointed end, while these large fossil implements were on the contrary obtuse and rounded, often, indeed, altogether untrimmed and massive at the broad end, and worked to a cutting edge or point at the opposite extremity.

The extent of geographical area over which these flints have been met with, and the similarity of their forms at distant places was then dwelt upon, as further collateral evidences of their artificial workmanship; for it was contrary to reason to suppose that natural means should produce stones of the same fashion in Europe, Asia, and Africa.

The author then proceeded to suggest the uses of these various objects, and to illustrate them by recent examples from the South Sea islands, New Zealand, and Canada, &c. The purposes of the arrow-heads, javelin-points, knives, and other flake instruments were readily recognizable by mere comparison, but the determination of the uses of the larger so-called "celts" was more difficult. One sort seemed adapted for spear-heads, another for digging roots, and some authors had suggested that others of smaller size were probably made for sling-stones, a use which seemed to the author as somewhat doubtful.

In conclusion the author mentioned instances of the bones of the great fossil terrestrial beasts which swarmed on the earth during the Pleistocene period, and whose bones were found associated with these earliest remains of human workmanship, having been found marked with incisions such as might be made by stone weapons. One instance of an injured fossil bone of the Irish elk is mentioned in Professor Owen's "British Fossil Mammalia;" and several examples have been recently recorded in France, by M. Lartet.

The author concluded by suggesting how desirable he thought it that the members of the Association should interest themselves in this important inquiry; and reminded them that at Ilford, Grays, and numerous other places round London mammalian deposits were known, and in these it was well worthy the geologist's time to make strict search, as well as at Reigate and other places, where numerous flint arrow-heads, not certainly known to be fossil, had been found.

The fact that the earliest discovered fossil flint "celt" was found in London itself (in Gray's Inn) was an encouragement to the further investigating the metropolitan area.

A discussion followed the reading of the paper, in which Professor Macdonald, Professor Tennant, Mr. Cumming, Mr. F. Braby, Mr. Lawson, and other members took part.

Ordinary Meeting, 2nd July, 1860.

The Rev. Thos. Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association: Rev. T. C. Wilks; W. D. Glyde, Esq.; and James Marder, Esq.

The following donations were announced:—

Lord Wrottesley's Address at the Meeting of the British Association for the Advancement of Science. From the Rev. T. Wiltshire.

"The Geologist" magazine for May, June, and July. From the editor.

"On the Basement Bed of the Keuper Formation in Wirral and the South West of Lancashire." By G. H. Morton, Esq., F.G.S. From the author.

The following papers were read:—

1.—"On the Kentish Ragstone as exhibited in the Iguanodon Quarry at Maidstone." By W. H. Bensted, Esq.

The author stated the Kentish Ragstone to be a member of the Lower Greensand series, describing it as generally underlying a dark coarse sand of about six feet in thickness. The surface of the rock appears in large concretionary nodules, slightly ferruginous, and of rough texture. In regular alternations of limestone and hassock, the formation continues downwards for about eighty feet, where it rests upon the Atherfield clay, the lowest member of the Lower Greensand. The Weald clay then occurs, and is of very considerable thickness, borings at Maidstone having penetrated to the depth of five and six hundred feet.

The texture of this ragstone was stated to vary very considerably.

Some of the beds are composed of chert and black flint, but the prevailing characteristic is a blue limestone lying in thicknesses of from six inches to three feet. The stratification also is very irregular, the same stratum varying from twelve inches to two or three feet in thickness.

The author then referred to the great disruption of masses of rock which is exhibited at Maidstone, showing that in a line from that town to the great escarpment of ragstone at Linton, which bassets out over the Wealden at about four miles distance, there occur large masses of rock separated from one another, and having the interstices filled up with brick earth, clay, sand, and drift, the latter mostly derived from the immediate neighbourhood.

These interstices are worked as brickfields to a large extent, and bones and teeth of *Elephas primigenius*, with remains of rhinoceros, deer, and horse are frequently met with.

The Iguanodon quarry belonging to the author was then particularly described. This quarry takes its name from its having been the place in which the remains of the iguanodon described by Dr. Mantell, and now in the British Museum, were found.

The face of the rock, or, as it is provincially termed, "cliff," is here about seventy feet in height, and above it lies a bed of coarse green sand about eight feet in thickness, surmounted by about five feet of yellow sand, the surface soil being immediately over the latter. The vertical fissures show the lines of subsidence, and being filled with gravel detritus, present an arrangement similar to the "sand pipes" of the chalk. This gravel is composed of angular chalk flints, flint pebbles, water-worn sub-angular fragments of the Hastings sandstone, and a few pieces of ironstone from the same beds, with angular chert, and rarely, quartz pebbles.

The author is of opinion that after the subsidence of these sands and gravels a lateral force was exerted on the ragstone beds, causing in some places a contorted appearance in the materials of the fissures. This opinion is strengthened by the existence of highly polished planes of Slickensides, which appear to be owing to some such force. Further proof of this may be seen in the circumstance that the under surface of the projecting rock is entirely filled up, an effect which could not have been produced by an action of subsidence only.

The author next alluded to traces of very ancient water-courses of considerable size and extent, which occur in the form of caverns in a bed of sandstone (locally called hassock). These appear to have existed previously to the disruption of the general mass, and to have been formed by an underground action of water at a period when the levels of the springs in the neighbourhood were in a very different position from that in which they are now found. In one of such caverns the author stated he had discovered adhering to the rock a very perfect specimen of fossil sponge, the spiculæ intact, and the channels perfect. Such a fact as that just described proved that the force of the water must have been gentle as well as long continued, otherwise the removal of the sand in which the sponge was embedded would have injured the structure. The erosive power, however, must have been great, for wherever the water had acted upon the limestone, the surface was worn away, and projections of flint veins were observed standing out from their limestone matrix, similar to the sponge.

The author, therefore, considered it probable that the water was impregnated with carbonic acid, which would thus by its chemical action assist the erosion of the surface of the limestone rock.

The present fissures are contiguous down to the water-line, and afford means of drainage by which the water flows out into the valley of the Medway.

Each layer in the Quarry is of a distinct character, both as to texture and structure. In certain beds fossils occur with some regularity, *Trigonia aliformis* being a characteristic shell of the Greensand formation, and found all through the series.

The stratum immediately below the bed in which the iguanodon was found abounds in casts of shells and dark coloured bodies, probably coprolitic. Most of the common shells are met with in this layer. A paper was read by the late Dr. Mantell at the Geological Society, and the term molluskite was applied to these dark substances. There are two more strata at about eight feet apart, which contain very much the same remains.

Waterworn fragments of wood occur very frequently in various states of preservation, from a hard silicified state to a soft pulpy mass. A layer low down in the series contains a large quantity of detached spiculæ of dead sponges, in which a fine specimen of marine turtle was discovered by the author. This is described by Professor Owen in his "Palæontology of the Weald." An interesting circumstance in connection with this fossil is observable in the fact of its being embedded in fine sandstone with spiculæ, the recent remains of the turtle in those regions which it inhabits being found similarly associated with spiculæ and fine sand of the present age.

Numerous traces of *Fuci* are met with in nearly all the beds. The author has collected from this quarry a series of specimens to illustrate a species of *Siphonia* of a very remarkable kind. It consists of an upright stem varying in length from a few inches to two feet, the stem at intervals bulging out into a lobe, and some stems having three or four lobes. The head or top lobe is often of large size, and takes the nodulus figure of a chalk flint. On breaking some of them, a small lobe with portions of the stem is found within. The most curious part of this zoophyte is an attachment of Tentaculæ shooting out from the stem, and these are similar to a string of beads, sometimes single and sometimes double; in fact, no two specimens are alike, and it is only by comparing many specimens together that the nature and figure of this fossil can be understood.

The author mentioned the following as some of the fossils found by him in his quarry:—

The Maidstone Iguanodon, now in the British Museum.

Four teeth of Polyptychodon.

Portion of Plesiosaurus, now in the British Museum.

Fragment of wingbone of Pterodactyle.

Vertebræ of Saurians, several.

Two portions of jaw of Crocodile.

Mandible of Chimæra, several specimens.

Marine Turtle.

Siphonia monilia.

Abies Benstedi.

Dracœna Benstedi.

2.—On the Mastoid Appearances exhibited on the Faced Flints employed for the Outer Walls of Buildings. By C. B. Rose, Esq., F.G.S., etc.

Flint is met with in the Cretaceous districts in two principal forms, viz., the tabular and the cylindrico-spherical, or nodular; the former occurs in the upper chalk strata, in vertical, oblique, or horizontal seams, from about a quarter of an inch in thickness to tables of the thickness of twelve inches. The natural fracture of the tabular form is into laminæ possessing a thin edge on one line, with a thicker in an opposite parallel line, thus adapting it to the formation of gun-flints. The fracture of the nodular form, when directed transversely through the cylinder, is conchoidal, forming a more or less oblique nipple. There is a third form of fracture not unfrequently met with, which I think is best described by the term "shattery." This disintegration may probably be the result of weathering, or arises from an infiltration of iron or iron-pyrites, when it is vulgarly called "rotten flint."

My attention was first called to the somewhat remarkable feature on the face of the flints in the ancient towers and wall of the town of Yarmouth by Mr. Owles, a chemist of the place, as an appearance that he could not account for. On examining the spot he directed me to, I at once saw that it must arise from conchoidal fracture.

I extended my examination to the towers and other portions of the ancient wall, and invariably found the same mastoid surface upon a large proportion of the flints. I have also examined the exterior walls of monastic edifices and ancient private dwellings at Norwich, and they exhibited precisely similar features: the walls of the Guildhall beautifully displayed the papillæ. I now carried my inquiry into the state of the face of flints in modern and very recently built walls, and in not a single instance could I find the mastoid character. Thus, then, it seemed evident that time had something to do with the production of the change of feature, and to test that point I took an opportunity of examining the walls at Burgh Castle, in the vicinity of Yarmouth, an undoubted Roman remain. There I found the mastoid character on the flinty face of the wall, but not to the extent I expected from the age of the work; and this circumstance led me naturally to think there must be some other agent in the evolution of the papillæ, and induced me to examine our old wall more minutely. I then observed that on the face of the papillated flints, as well as on some of those which were not so marked, there occurred shivery crescent-like flaws, which on exposing the flint to repeated forcible concussions with a hammer led to the flaking off of the shivers, exposing a cup-like cavity, having a nipple within it, resembling in all respects those which had occurred

Fig. 1.—Fragment of flint from Norfolk, showing the cup-like cavities and papillæ. *a*, papillæ fully formed; *b*, apex of papilla just visible through the flakes.

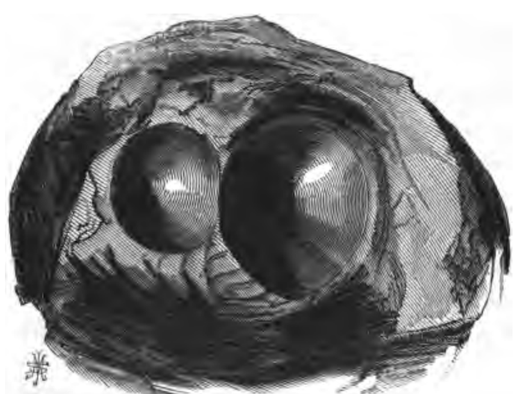


Fig. 2.—Specimen from Gravesend, showing the mastoid appearance formed by fracture.

spontaneously, I conceive then that the insinuation of moisture into the flaws, acted upon by frost, loosens the fissured flint, and in time leads to the exfoliation which lays open the conchoidal cleavage of the stone. I present illustrative specimens.

It appears from the above data that the state of the face of the flints will be some criterion of the age of the building.

Some fossils from the London Clay at Dulwich were exhibited by Mr. Bott.

It was resolved, That the thanks of the Association be given to Mr. Bensted for his courtesy shown to the members on the occasion of the late excursion to Maidstone, on the 19th ult.

It was also resolved, That the thanks of the Association be given to the President, Treasurer, and Secretary, for their attention to the business of the Association.

The President gave notice that the Committee had determined upon conducting an excursion to Dulwich, on the 31st July, for the purpose of examining the sections exposed at the works of the Metropolitan Main Drainage at that place.

The President announced that in consequence of the College of Dentists, of whom the Association rents the rooms occupied by it in Cavendish Square, being about to determine their tenancy of the rooms, it had become requisite to seek fresh apartments for the accommodation of the Association. The President also announced that in compliance with Rule 29, the Association would not meet again until Monday the 5th of November next, and accordingly

The Meeting was adjourned to that day.

In accordance with the intimation given at the meeting of the 7th of May, a large number of the members visited Maidstone on Tuesday, the 19th of June.

The party, which was under the guidance of the President, Professor Tennant, and Mr. Bensted, first inspected the Iguanodon quarry belonging to the last-named gentleman, in the neighbourhood of the town. A description of this quarry is contained in Mr. Bensted's paper, an abstract of which is given above. Some remarkable vertical fissures occur here; and some good examples of slickensides were observed. The party then visited the Museum in the town, where they had an opportunity of seeing the fossil remains collected by the late Mr. Charles.

After partaking of refreshment, a portion of the party proceeded to Kit's Coty House. This is a Druidical monument composed of three upright stones, surmounted by a very massive roof-stone. The materials have been derived from the consolidated sand of the Woolwich series, which rests immediately upon the chalk on the top of Bluebell Hill, in the neighbouhood. The larger stones in Stonehenge are of the same material, which, from its application to such monuments as these has acquired the name of Druid Sandstone. The whole party then proceeded to Aylesford, where they examined a remarkable bed of River Drift. They returned to town in the evening.

It having been found impracticable, owing to an influx of water into the works at Dulwich, to carry out the excursion announced at the last meeting, the Committee made arrangements for an excursion to Charlton instead. Accordingly, on the afternoon of Monday, Aug. 13th, a large party of the members, accompanied by the President and Professor Tennant, visited that place, and spent some time in examining the points of geological interest in the vicinity, returning to town in the evening.

Four stereoscopic pictures, illustrative of points of interest visited during the excursion to Maidstone, have been taken by one of the members. The subjects are, the Iguanodon Quarry, as seen from the north, north-east, and east, and Kit's Coty House. The negatives have been placed at the disposal of the Committee, and each member will therefore receive a photograph of the Quarry with this abstract. Any member wishing for the remaining three photographs can have them on payment of two shillings (the cost of printing), either to the Secretary or to the Treasurer, Mr. Hislop, 108, St. John Street Road, London, E.C. If to be forwarded by post, the postage (threepence) must also be enclosed.

*** As soon as the Committee have succeeded in engaging rooms for the Association, due notice will be forwarded to the members. In the meantime it is requested that all communications may be addressed to the Secretary, Mr. Lawson, 28, Chancery Lane, London, W.C.

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

No. 6.] [Session 1860-61.

Ordinary Meeting, Monday, Nov. 5th, 1860.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association :—R. J .L. Guppy, Esq.; A. Hockley, Esq.; W. B. Kesteven, Esq.; T. P. Moody, Esq.; and C. B. Rose, Esq., F.G.S., &c.

The following donations were announced :—

A Catalogue of Organic Remains from the Permian Rocks of Northumberland and Durham. By J. Pickering, Esq.

A Specimen of Pentremite. By the Rev. L. H. Mordacque.

Fossils from the Lias and Marlstone. By W. Myers, Esq.

The Rev. Walter Mitchell, M.A., gave a Lecture upon "The Application of Crystallography to Mineralogy and Geology."

Crystallography is a science of the greatest importance, both to the chemist and mineralogist. So far as these sciences are essential to the geologist, crystallography must bear its share. It is however of some special advantage to the geologist. There are certain veins or rents in rocks which have been filled with mineral substances; these substances have formed crystals, either by cooling from a fluid state, by sublimation, or by being deposited from solutions the fluid portion of which has evaporated.

Sometimes a part, or the whole, of these crystalline substances may be removed, yet the trace of the previous existence of those so removed may be faithfully preserved.

Thus, crystals of carbonate of lime may be first deposited. These crystals may be completely coated over with others of quartz. The carbonate of lime may then be removed by some solvent acting upon that substance, but having no effect on the quartz; there is then left a mould of the carbonate of lime crystal in the quartz. This may then be filled by some other substance which would not naturally assume the form in the mould of which it is deposited. A crystal so formed is called a pseudo-morphous form. It indicates to the geologist or mineralogist the certain proof of the previous existence of a body in the vein, which has been afterwards removed by some geological change. Those who are familiar with rocks know how frequently the successive crops of crystals which have been deposited in their veins point out the successive injection into them of various mineral substances. But there is one other point to which I may call your attention; and that is, to a fact which seems to be slowly evolving itself, namely, that crystals are natural pyrometers. They afford a means of obtaining the temperature at which they have been formed. I may show this by an experiment within the reach of everyone. Make a solution of common alum in boiling water, putting into the water as much alum as it will dissolve. Hang up in this solution a few threads or wires. As the solution cools, these threads will be covered with beautiful transparent crystals. If these crystals be taken out of the solution, and examined before it has cooled to the ordinary temperature of the atmosphere, these crystals will present faces of the regular octahedron only;—the octahedron being a form which is bounded by eight equilateral triangles. Having examined these crystals, hang them again in the solution, and leave them a day or two in it, at the ordinary temperature of the atmosphere. Take them out again; you will find they have grown, but grown in such a manner as to lose their octahedral forms. Their solid pointed angles will all be replaced or cut off by planes, which are squares. These planes are parallel to those of a cube, and the new crystals are said to be combinations of the two forms of the cube and octahedron. If crystals be formed not about the octahedral nuclei in this same solution, but allowed to deposit themselves spontaneously, they will take on the form of the perfect cube. The form of a crystal of alum, whether it be that of an octahedron or a cube, or a combination of these two, affords a certain indication of the temperature at which it was produced. Common salt, crystallized at the ordinary temperature of the air, forms cubes. If it be rapidly crystallized, however, on a piece of heated glass, it produces octahedrons. The same influence of temperature is shown in the case of carbonate of lime. Dr. Miller tells us that if it is crystallized from its solution in water containing carbonic acid, at the temperature of boiling water, or is precipitated by pouring a boiling hot solution of chloride of calcium into a solution of carbonate of ammonia, also boiling hot, it takes the form of aragonite. When it crystallizes from a solution at the ordinary temperature of the atmosphere, or from fusion, it takes the form of Iceland Spar. Thus we find that the influence of temperature not only applies to those forms of crystals which belong to the same system, but also, as in the case of carbonate of lime, to what are called dimorphous bodies, because they assume forms pertaining to two different systems of crystallization. The observations made with regard to carbonate of lime apply also to common nitre, which is isodimorphous with it. These instances are by no means solitary examples of the influence of temperature on the forms of crystals. Should it be found to follow a general law, crystallography will afford the geologist one of the most important means of determining the history of the formation of crystalline rocks.

Mr. Clifton Sorby has made an important application of the subject of crystallography to geology. He has called in the aid of the microscope. He makes thin sections of granitic and other rocks composed of crystals. These crystals have many minute holes or pores. If the crystal has been formed from a fluid solution, these minute pores are seen under the microscope partially filled with liquid. If they have been formed by slow cooling from a molten mass, the pores indicate this fact. By these means Mr. Sorby has been enabled to deduce some important geological theories.

There is one other geological subject on which crystallography throws some light. The very difficult one of slaty cleavage. The cleavage of crystals affords almost the only means of arriving at the laws of those definite directions in which the slaty rocks are so often split. Having made these few observations on the application of crystallography to geology, I may, perhaps, be permitted to make some few observations on the easiest method of studying this subject.

When the particles of any substance assume a solid form, provided those particles are allowed to arrange themselves under the influence of their mutual attractions, they will assume the form of crystals. These forms are almost always bounded by perfectly flat or plane surfaces. In the few instances where they appear curved, the curvature is more apparent than real. The appearance of curvature being caused by a number of planes slightly inclined to each other.

Crystals may be formed in a variety of ways. They may be formed by the evaporation of a fluid which holds the crystalline substance in solution. They may be formed by the passage of a body from the fluid to the solid state, as in the case of most metals. They may likewise be formed by being deposited from the vapour of a volatilized body.

Sulphur affords an example of crystals formed by each of these methods. Crystals of sulphur may be deposited from its solution in naphtha, or some hydrocarbon. They may be obtained by pouring melted sulphur in a molten state into a mould, waiting until the surface is solid. The solid crust is then broken, the molten mass still fluid in the interior is poured out, and the inner crust is found studded with crystals. The beautiful crystals of sulphur found on lava in volcanic districts are formed by being deposited from the sublimed vapour of that body.

I have already called your attention to the formation of crystals from solutions of substances. Bismuth, melted and cooled, as I have mentioned in the case of sulphur, affords an interesting example of metallic crystals. With regard to the formation of crystals by sublimation, I may instance the value of the appearance of the crystals of arsenious acid as obtained by the sublimation of arsenic. This affords the chemist his ultimate test for the presence of the most minute portion of this deadly substance in any fluid or substance, however skilfully disguised.

To obtain that elementary knowledge of crystallography which is so useful, both to the chemist and mineralogist, we must take some few lessons on form. We must be able to recognize the principal crystals, in whatever direction they present themselves to our view. If we wish to make a more extended acquaintance with the laws of crystallography, we must make ourselves masters of a considerable portion of solid geometry. To attain this, there is, as you are well aware, no royal road. Its difficulties may, however, be considerably smoothed, and a useful knowledge acquired, by very simple means.

I would strongly recommend every person commencing the study of crystallography to make models of the chief forms for himself. You will learn more by making one model for yourself, you will become more familiar with its appearance under different aspects, in one half-hour thus employed, than by days of study without this aid. The reason why solid geometry is so repulsive to many minds is, that they attempt to master it simply by drawings on a plane surface. Whereas, if they would use—or, better still, make—a model of the form to be studied or investigated for themselves, solid geometry would become as easy and intelligible as plane geometry.

Thus, if you describe on a piece of pasteboard an equilateral triangle, which anyone can do from the first proposition in Euclid, bisect each of the sides of this triangle, which, as its name implies, are all equal, and draw lines joining each of these points of bisection, the triangle will be divided into four equilateral triangles. Now, if we cut out the original triangle with a pair of scissors, and draw a pen-knife lightly over the three lines joining the bisected edges, so as to cut only half through the pasteboard, the flat piece of pasteboard will readily fold up into the form of a regular pyramid on a triangular base. The edges may be fastened together with a dot of sealing-wax, or a little glue, and you will have a very good model of the regular tetrahedron. This is one of the Platonic bodies, or regular solids, and occurs also in nature, as the form of a crystal. Eight such triangles as these, arranged in this manner (indicated by the lecturer on a black board), will give the regular octahedron. This form is bounded by eight equilateral triangles, and is another of the Platonic bodies, and occurs as a very common form among crystals. Now, by making two such models as these, handling them and viewing them in every aspect, you will learn properties and appearances of these forms which you could never familiarize yourself with by drawings of them on a flat surface.

A cube is easily formed by arranging on the cardboard six squares in the form of a Roman cross. The diagrams for cutting out the principal forms of crystals are now given in many books of crystallography. They are called "nets" for crystals.

All crystals are not so simple in their forms as these. There are many crystals described, having hundreds of faces or planes on the same crystal. The varieties of forms are endless. Many hundred forms of crystals —each of these forms possessing from six to more than a hundred faces— have been drawn, described, and measured, composed of only one substance, carbonate of lime. Now, it is one branch of crystallography to read, describe, and reduce these complicated forms to their simplest and most symmetrical elements. These complex crystals of carbonate of lime defied all the powers of Haüy to resolve them into their simple elements, until one day he accidentally broke a magnificent crystal. Gathering the fragments into which it had broken, he was surprised by their similarity. He measured the angles of these fragments; he found all that came from the interior of the crystal gave but two angles; he broke these fragments into smaller ones; he obtained still these two angles, and no others. He broke other crystals of carbonate of lime; all alike gave similar fragments, with identically the same angles. He then tried to break crystals of other substances. He found some of these readily giving simpler forms than the external crystal; these simple forms having angles which were identical for crystals of the same substance, but differing for different substances. This law of cleavage, as it is called, gave Haüy the hint for simplifying the forms of crystals. He arranged all known forms under six distinct groups or families—a division which remains to the present time.

I cannot, in the course of an hour, enter into the description of all these groups; I will therefore confine my remarks to the first, or, as it is called, the cubical or octahedral system. It is called the cubical or octahedral according as you take the cube or octahedron as the typical form of the system.

In this country, fluor spar generally crystallizes in the form of the cube. Take one of these cubes, and draw diagonals across every one of its six square faces or planes, as I do on this model. Now take a knife, place its edge along one of these diagonals, and incline the blade of the knife in the direction of the two diagonals of the two squares which join the two extremities of the diagonal on which the knife is placed. Give the back of the knife a sharp blow with a hammer, and a piece will be split off the cube bounded by the three adjacent diagonals. A new face will now be exposed, which will be an equilateral triangle. Proceeding in this way with the remaining square faces, we shall detach three more fragments, displaying three more triangular faces. The piece which remains will be a regular solid, bounded by four equal equilateral triangles. We thus obtain by the law of cleavage a regular tetrahedron from a cube of fluor spar.

We now take this regular tetrahedron—it has six equal edges. We bisect each of these edges, and join the points of bisection by scratching lines on the crystal. We place the edge of the knife on one of these lines, and hold the blade in the direction of two similar lines on two adjacent faces to the one on which we place the edge. We give another blow with the hammer, and we detach a fragment which, on examination, proves to be itself a regular tetrahedron. This we have obtained by splitting off one of the solid angles of the original tetrahedron. We proceed in like manner to split off the remaining three solid angles. The nucleus which remains is another regular solid body. It is bounded by eight equal equilateral triangles, and is the regular octahedron. Hence, by cleavage we have obtained from the cube of fluor spar two of the Platonic bodies, the cube itself being another. Replacing our fragments, we may readily see how the tetrahedron has been geometrically inscribed in the cube, and the octahedron in the tetrahedron. In point of fact, you will discover that nature itself has demonstrated to you two propositions out of the last, the fifteenth book of Euclid. A matter perhaps not insignificant, if we remember that Plato only described these three of the so called Platonic bodies, and that he prophesied that they contained hidden in their properties the secrets of all material laws. We thus find by cleavage a natural connection between the three forms—the cube, octahedron, and tetrahedron. The diamond possesses the same properties—so far as crystalline form and cleavage is concerned—as fluor spar. All crystals of the diamond, though that substance is the hardest in nature, break readily, cleave or split in the direction of the regular octahedron; these directions of cleavage having always a definite relation to the external form of the crystal.

The diamond not only has the octahedral cleavage above described—so that out of a diamond crystal in the form of a cube you can easily split out a tetrahedron and an octahedron—but its crystals, without cleavage, may assume these two forms. Besides these two forms, the diamond may assume other simple forms; all differing considerably from one another. More puzzling still, these forms may be combined in the same crystal. Thus a cube may have its solid angles cut off, or replaced, as it is called, by eight equilateral triangles. These eight triangular faces are parallel to the imaginary or cleavage octahedron inscribed in the cube; we call them, therefore, octahedral faces. The crystal is said to be a combination of the cube and octahedron. Among the simple forms of the crystals of the diamond is a very pretty symmetrical form, bounded by twelve planes. Each of these planes are rhombs or lozenges. It is called the rhombic dodecahedron. It is a very common form of the garnet. Half of this rhombic dodecahedron is a perfect mould of the bee's cell. If you hold it in such a position as to look down on one of its solid angles formed by the union of three planes, you will see that these three planes, or lozenges, represent the bottom of a bee's cell, and the six adjacent faces the six walls of the hexagonal cell. Moreover, the angles of these rhombs are identically those of the bee's cell. The larger plane angle is 109° 28′; the smaller 70° 32′—the very angles which give to the bee's cell the greatest space with greatest economy of material. Long before man dreamt of the rhombic dodecahedron, the same great Geometer who impressed on the diamond the laws by which its particles are governed, taught the bee to solve a problem which we could not interpret without a profound knowledge of geometry. Thousands of different angles might have been devised, every one of which would have terminated the bee's cell with three lozenges of equal thickness with the sides; none but these two would have given the bee the palm over all natural architects. Instinct in this case led to the detection of the blunders of reason. A patient German naturalist discovered that the great angle of the bee's lozenge was invariably 109° 28′. A mathematician calculated what it should be to give the greatest possible economy of material with the greatest amount of space; he arrived at the angle 109° 26′. He thought the bee had made the small error of 2′. Subsequent examination, however, showed the bee to be right; and that the mathematician had been misled by a blunder in his logarithmic tables.

These three forms of the cubical system—the cube, octahedron, and rhombic dodecahedron—are called the three invariable forms of the system. Their angles, whether of the inclination of their faces to each other, or of the sides of the faces to each other, are invariable. Between these forms there are other variable forms which, while retaining a general resemblance to each other, vary in their angles.

[The relationship of these variable forms to each other, and the invariable forms of the cubical system, Mr. Mitchell demonstrated by models and coloured diagrams. Lastly, he showed by a kind of armillary sphere, in which an octahedron was inscribed, how all these forms might be made to pass from one to the other, through all their infinite changes, by only pulling two different strings. This portion of the lecture cannot be given without the aid of the models and diagrams.]

A discussion followed, in which several members took part, and in the course of which Professor Tennant said that the lecturer had had a difficulty in condensing this very comprehensive subject. He had been giving the pith of twelve lectures in one hour; which was like giving the history of England in the same time. Crystals formed, as it were, the flowers of minerals; and held the same relation to the inorganic kingdom as flowers did to the vegetable. A person in California found a substance, and not knowing what it was, took it to a jeweller for examination. The jeweller took a file and tried to file it, but could not; he then drew it across a piece of glass, and found that it scratched the glass. Supposing it to be a diamond, the jeweller offered £200 for it. "Oh," said the finder, "if it is worth £200 to you, I am going to England, and will take it with me." He showed it to several jewellers in England who knew no better. He then brought it to him (Mr. Tennant) with a letter from a friend, asking him to examine the substance. He asked what was the value of the stone. To which he (Mr. Tennant) replied, "If you went to buy it, perhaps you would have to give four or five shillings for it; but if you want a quantity of them, I dare say you could have them for a couple of shillings or half-a-crown each." The substance was a transparent crystal of quartz, in the form of a six-sided prism, terminated at each end by a six-sided pyramid; the diamond never occurs in this form, but usually in the shape of an octahedron or rhombic dodecahedron.

Now, this was one of the practical applications of crystallography. He showed him also that its quality could also be known from its specific gravity. The owner stated that it would scratch glass; on which he (Mr. Tennant) showed that a flint would scratch glass, and so would sand, the topaz, the emerald, corundum, and many other stones. He was sorry to say that crystallography was a subject very much neglected; though in France and Germany they knew more about it than in England. At the close of the Exhibition of 1851 the Koh-i-noor diamond was found to contain some flaws. He and Mr. Mitchell were sent for to Buckingham Palace, to see how large a perfect form could be obtained from the imperfect one. A calculation was made, and instruc-

tions were given to a lapidary at Amsterdam to reduce the diamond to the perfect form. It weighed 186 carats in the Exhibition, and was reduced to 103½ carats in the process of rubbing off the broken pieces. The same workman had since been engaged in cutting the "Star of the South," a very large diamond exhibited at the Paris Exhibition. Going through the interesting diamond cutting works the other day, at Amsterdam, he found about one thousand persons employed in cutting diamonds. The workmen were all of the Jewish persuasion. His friend, Professor Pole,* was with him. A wheel was used during the process, and revolved at the rate of 800 times a minute; and could be regulated to any required speed. Nine-tenths of the workmen knew nothing of crystallography, and were only guided by long practice. He (Mr. Tennant) was grateful to Mr. Mitchell, not only for this lecture, but for the lectures which he had delivered to Mr. Tennant's students at King's College. It might be asked, of what use was this science to geology? What was geology? The science of crystallography formed part of the alphabet of mineralogy. The geologist had to be a palæontologist, a conchologist, a mineralogist, a chemist, and a botanist.

Ordinary Meeting, Monday, 3rd December, 1860.

The Rev. T. Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association :— Rev. R. Bingham, M.A.; R. G. Clutton, Esq.; and J. R. Markby, Esq.

The following donations were announced:—

"The Abstracts of the Proceedings of the Geological Society." By the Geological Society.

A series of Fifty species of Land and Fresh-water Shells, from the Tertiary Upper Deposits at Copford, in Essex. By J. Pickering, Esq.

J. Cumming, Esq., and R. Farmer, Esq., were, in accordance with Rule 30, elected to audit the Accounts at the Annual General Meeting, on January 7th, 1861.

* See a paper on "Diamonds," by W. Pole, F.G.S., in *Macmillan's Magazine*, for January, 1861.

The following papers were read :—

1.—" On a New Red Sandstone Quarry at Stourton, in Cheshire." By J. H. Mitchener, Esq.

An hour's sharp walking from Birkenhead, striking off through the village of Tranmere, will enable a tolerable pedestrian to arrive at a neatly-erected stone, placed on the highest of a range of hills, from which he may learn the precise number of feet he then happens to be standing above the river Mersey—a height, according to the authority of the Geological Survey of Great Britain, the most elevated in the county of Cheshire. Half a mile from this spot lies the village of Stourton, whose quarries supply the material for constructing the greater portion of the churches, chapels, and other public buildings of the north. The public road, on either side of which the stone is excavated, runs parallel with, and is constructed on, the anticlinal axis of the stratum, the beds sloping off to the right and left. A transverse section of the anticlinal ridge discovers an appearance somewhat singular and unusual, for the central and highest portion has all the appearance of stratification, yet in a perpendicular position, and at right angles to the dip of the true beds. After much patient investigation and actual experiment, it was shown by the late Dr. Buckland to be the result of pressure, consequent on the withdrawal of the upheaving force ; thereby subjecting the intervening mass to heat so intense, as to induce a laminated semblance to stratification.

The quarry to the left of the road exposes some fifty feet of the new red sandstone. The upper portion, about twenty feet in thickness, is of a dull red colour, from which the stratum takes its name. It is of a coarse texture, somewhat soft when first worked, but hardens on exposure to the atmosphere. Between this and the lighter-coloured stone below, and forming a line of demarcation between them, is a thin shale of not more than one inch in thickness. This narrow strip does not appear in any place to widen out. It can be detected and followed, in whatever part of the neighbourhood the stone is quarried, separating the darker from the lighter-coloured bed. The latter is a fine-grained compact stone, of a pale yellow or cream tint. It is this stratum that is principally sought for building purposes. About thirty feet lies open to examination, though probably it attains to double that number in thickness.

In point of palæontological interest, the new red sandstone contrasts unfavourably with the rich fossilliferous beds of the period immediately succeeding; and Stourton Quarry can scarcely be quoted as an exception. The eye wanders up and down its lofty sandstone sides, but scans in vain the vast mass of rock for a solitary bivalve. Apparently, it is a sepulchre untenanted—a blank page in the rock-recorded history of our planet's former inhabitants. Not a fossil of any kind is visible, as if the period, being thoroughly ashamed of its population, had, by means of a ceaseless shifting of its grinding particles, so far succeeded in pulverizing their remains, as completely to obliterate all traces of their existence.

The thin shale before described has, to the utmost of its limited dimensions, compensated for the general dearth, and endeavoured to redeem the palæontological interest of the triassic. Here are found the only relics of the creatures in the shape of their foot-prints. Nearly all the impressions are of animals belonging to the order of Batrachians. The chubby foot of the Labyrinthodon (*Labyrinthodon pachygnathus* of Owen) is now becoming somewhat scarce at Stourton; the more elongated toes of the Cheirotherium of Professor Kaup are more frequently met with. In the full-grown animal of the latter species, the hind-foot of the largest specimen I have found has measured ten inches in length, and the step nearly two feet. The fore-foot is very small, as in all creatures of the toad kind. Some of the foot-prints are sharp and well defined, others deeper and less intelligible, indicating an unequal consistency in the condition of the mud, when traversed by the animals; in some parts sufficiently hard to resist the pressure of the foot and admit of a sharp impression, in other places, by the foot sinking, little more is perceptible in the fossil than a confused hole. It is worthy of remark, these foot-prints, when discovered, and examined *in situ*, invariably point in the *same* direction. Unlike the wise men, however, who came from the east—judging from the position of the toes of the batrachians—they appear to have travelled from the opposite quarter.

On the slab immediately overlying the shale, capital casts of the impressions are found, which find their way into the various museums of the country.

By far the best specimen of the full-grown true Labyrinthodon the writer has yet met with, might some little time since have been seen on the top of a *pig-sty* belonging to one of the workmen. No geologist that visited Stourton Quarry but was dragged up its steep and rugged sides to view this unique, scientific gem, in its rather inelegant setting. A sight of it seldom fails to elicit from the visitor an exclamation of surprise and delight, and stimulates an interest in the study, such as the more honoured and aristocratically-preserved slabs of the Bloomsbury, Jermyn Street, Liverpool, or Manchester Museums, in vain attempt to inspire.

It shows three consecutive foot-prints of the hind and fore-paws, with a length of stride of about eighteen inches. Being the upper slab, and consequently a cast, the impressions are in relief, and, from the sharpness of their outline, very suggestive.

With a pertinacity for which quarrymen are remarkable, the workmen adhere to the statement of occasionally also finding live toads in the solid stone. The impression left by the Cheirotherium is known to them by the cognomen of the "lady's foot," though a single glance determines it considerably more to resemble that of a hippopotamus.

The upper slabs, bearing the casts of the foot-prints, may be seen in blocks lying about the quarry in all directions. An examination of some of them would almost induce a belief the animals themselves entertained a determination to destroy the evidences of their trail. No sooner does one of these geological Indians appear to have crossed the bank and left a fair impression, than another, in attempting to plant his foot in the same hole, and but partially succeeding—and this not unfrequently further improved by a third, diametrically across the two—renders identification almost as hopeless a task as that of deciphering the cuneiform characters of a Nineveh relic. Patient investigation, however, will generally induce the slab to confess to a Rhynchosaurus and some smaller companions of the period.

In the year 1841 a gigantic fucoid was discovered in the same quarry, and stretched over the rock to a length of eighty feet and upwards. When we remember that sea-weeds are frequently met with in the Atlantic 200 feet in length—occasionally, by-the-bye, mistaken for and described as sea-serpents—we see nothing unreasonable in the supposition that this fossil fucoid may possibly be found to attain another eighty feet in the stone yet unquarried.

After a drawing had been executed by Mr. Cunningham, F.G.S., for the British Museum, and casts taken of various portions of the stem and branchlets, it was broken up, and but a comparatively small fragment remains for the inspection of the occasional visitor. Unfortunately for science, the tiny ones of the cottagers are particularly partial to dancing on this spot; and their little feet are rapidly obliterating the characters of the specimen, and robbing the district of one of its ornaments of geological interest.

Passing from the centre of the quarry, through a short tunnel and longer cutting, to its outer extremity, the stone gradually assumes a less compact and more friable appearance. This continues the further we retreat, until, on arriving at the edge of this primæval sandbank, evidences of the influence of our satellite in the far by-gone of the Triassic is recorded in the successive sweepings of beautifully-delineated tidal marks.

Hard by this spot an accumulation of general *debris*, including boulders and other water-worn fragments of rocks foreign to the locality, intermingled with ice-grooved blocks of sandstone rudely deposited on the side of a hill, give evidences of the passage of the northern drift. The hammer, hitherto an useless incumbrance, now finds ample employment in boulder chipping. Greenstones (whose nearest parent rock must be sought in Cumberland), granitic emigrations from Scotland, basalts of Arthur's Seat origin, and endless chips of sundry old blocks of well-ascertained porphyries and serpentines, torn from their native beds by the irresistible influence of ice, carried away 300 miles from home—here commingle together to form a deposit of what may be designated twelve feet of *utter* confusion.

The district has received considerable attention from Mr. Cunningham, F.G.S., and Professor Archer, Director of the Scottish Museums.

In concluding these fragmentary remarks, I would briefly acknowledge my obligations to the latter gentleman, in whose company I visited Stourton Quarry.

2.—"On Brickfields, Gravel Pits, Sand Pits, and Peat Beds, at Copford, Fisherton, West Hackney, Reculvers, and Kennet Valley." By J. Pickering, Esq., Vice-President.

In placing before you this evening a series of interesting and mostly minute shells, consisting of 50 species (viz., 35 land and 15 fresh-water, the names of which are annexed at the close of this paper)—discovered and collected by my respected friend, the late Mr. John Brown, of Stanway, in the Upper Tertiary Deposit, at Copford, in Essex—I regret my inability to give much more information respecting them, from personal knowledge, than their mere identification. With their exact position *in situ* I am not acquainted, since the beds whence they were obtained were never visited by me; nor did I ever procure a closer inspection of them than could be had from the windows of a railway train. The first and only opportunity offered me of viewing the locality was whilst travelling to Ipswich, when, just after the train had passed beyond Marks Tey station, the Copford brickfield was pointed out to me as lying a little to the right of the embankment. And yet, although I have seen so little of the place, considerable quantities of the shells have passed through my hands for examination, and many hours have been spent in separating and determining their species, by means of a bull's-eye condenser, a moderately strong lens, and a pair of small and delicate brass pliers.

And now, having imparted to you the extent of my own knowledge, or rather want of it, on the subject, I will give some extracts in reference to these beds, from a paper by Mr. Brown, on the Upper Tertiaries at Copford, read before the Geological Society of London, and printed in their "Quarterly Journal," Vol. VIII., p. 184.

"The Copford fresh-water beds have been for several years extensively excavated to obtain brick earth, which is procured from three extensive workings, hereafter referred to as the western, eastern, and southern sections, respectively. Other sections of these beds have been discovered by casual excavations, and by borings to the west and south of the brick-field. This brickfield is about half-a-mile N.W. of Stanway Church, and lies between the railway and the high road, occupying about five acres. The ground slopes from the high road northward, to the flat marshy ground, which is crossed by the railway embankment.

"Although the Copford deposit cannot boast of such a long and varied list of fossil mammalia as those of Grays and Clacton, it is richer in land and fresh-water mollusca; that of Clacton having produced about fifty species, and Grays about forty-five species, while Copford has afforded sixty-nine species, as far as investigations in these deposits have hitherto gone.

"The beds forming this deposit run in the following order, commencing at the surface:—

"1. Brown clay, with pebbles, &c.

"1′. Brown sandy loam.

"2. Shell marl and ferruginous sand (furrowed surface), containing bones and shells.

"2′. The same, passing into clay, rich in shells.

"3. Vegetable bed, containing shells.

"4. Blue clay (brick earth) with bones and shells

"4′. Yellow clay, with 'race' } not laminated.

"4″. Yellow and blue clays, laminated.

"5. Grey sandy gravel, containing shells and drifted fossils.

"5′. Sandy gravel.

"In digging through the bed No. 4, the workmen met with a bed of sand and gravel (No. 5), with calcareous concretions, rounded chalk *debris*, flints—both rounded and angular, boulders of lias, and other rock fragments. This bed is very rich in fragments of *ammonites*, *ostreæ*, &c., and organic remains (for the most part small) derived from the lias, oolite, greensand, gault, chalk, and tertiary formations, with land and fresh-water shells.

"The bed No. 4 consists of blue clay, containing a large quantity of calcareous matter; it is about eleven feet in thickness, and its surface is undulated throughout. At the southern part of the eastern excavation this bed passes upwards into a yellow clay (No. 4′), six feet thick, with numerous small irregularly-rounded concretions of carbonate of lime ('race' of the workmen). In a section opened in the southern part of the field in 1836, and separated from the eastern section by a strip of ground that is not worked—consisting, probably, of bed No. 5, and forming, as it were, a ridge traversing the field from E. to W.—appears a yellow, sandy clay (No. 4″), laminated about ten feet thick, dipping to the south, and there passing into, and alternating with, similar clay of a blue colour. In this laminated yellow clay are found numerous thin calcareous concretions, flat and irregular in shape, as well as a few of the roundish calcareous bodies above mentioned; the yellow clay rests on a sandy gravel (No. 5′), towards the surface it sometimes contains much chalk *debris*, and at places it is seen to pass upwards into an obscurely laminated brown loam. In the western part of this excavation (which is somewhat basin-shaped), the yellow clay laminæ vary in their dip from S. to S.E., and to nearly E. This laminated yellow and blue clay is, in my opinion, the same as the blue clay of the eastern and western sections; which latter is co-extensive with the other beds hereafter mentioned, that occupy the site of what appears to have been an ancient fresh-water lake, being more than a mile in extent from east to west, and about three-quarters of a mile in a north and south direction.

"The clay undergoes a process of puddling and washing, in a horse-mill, preparatory to its being used in brickmaking; and from the *debris* of these washings various organic remains and rock fragments have been obtained, rolled fragments of chalk, rolled and angular flints, fragments of Kimmeridge clay, and minute fossils from the upper secondary rocks.

"I formerly noticed the occurrence of fragments of fresh-water shells in the upper part of the blue clay (No. 4), especially *Valvata* and opercula of *Bithinia;* on a recent examination of portions of this bed, nine species of fresh-water shells, and three species of *Foraminifera* of existing forms were discerned.

"The shells are much more abundant in the upper part of the clay than below, which latter is mixed with siliceous sand, ferruginous grains, minute fragments of chalk, and a few of the most common chalk *Foraminifera,* together with portions of *Sphagnum.*

"Bones of the elephant, stag, aurochs, bear, and beaver have been obtained from the blue clay.

"On this calcareous clay we have a very compact deposit of vegetable matter (No. 3), generally from three to twelve inches thick, but at the eastern section it increases southward to a thickness of six or seven feet. It is similar to peat, but not so inflammable, having a small portion of argillaceous matter distributed throughout its mass; it is often incorporated with the upper portion of the blue clay. In this bed have been found compressed branches of trees, and shells of *Valvata piscinalis,* and, in 1836, I found *Cyclas rivicola* in groups.

"Over this layer of vegetable matter there occurs a bed of shell marl, (No. 2), from one to six feet thick, which lies conformably on the undulatory surface of the blue clay, into which it sometimes sends down oblique veins (west section). This bed dips to the north with a slight angle (about 5°), and thins out towards the southern part of the brick-field. It varies considerably in its character throughout this area, sometimes consisting wholly of a white calcareous marl, having a chalky appearance, and sometimes of the latter, alternating with ferruginous sands, or passing into sand or clay. In the western excavation it is chiefly composed of white sand and shell fragments (*Valvata piscinalis*). In the first-named condition no shells or parts of shells have been found in it, although, most probably, it is wholly derived from the decomposition of accumulated remains of dead molluscs. When it becomes sandy, however, both broken and perfect shells are not rare; but when it passes into clay, the remains ot land and fresh-water molluscs are abundantly found in a perfect state. In the light-coloured clay (No. 2′), into which the marl passes in one part of the eastern section, exposed in 1850, thirty-two species have been found, of which two are extinct, viz., *Helix incarnata ?* and *Helix ruderata*.

"In this marl the horn-core, and bones of ox, antlers of stag, and bones of elephant, have been met with.

"Overlying the white marl is an unstratified deposit of reddish-brown clay (No. 1), containing chalk nodules, rounded and angular flints, boulders of grey-wether, and other sandstones, limestones, conglomerates, and porphyritic rocks. This clay is from one to six feet thick, the greatest thickness occurring in the northern part of the field. To the south it passes over the limit of the marl beds, and rests on the yellow bed into which the blue clay or brick earth passes. No organic remains have been found in this brown clay excepting a molar tooth of a horse, and this was obtained near its junction with the white marl.

"At the western and northern parts of the field there is a superficial bed of peat, about one foot in thickness, with recent land and fresh-water shells, many of which retain their epidermis.*

"Having thus described the Copford deposits in detail, I would observe that the sandy gravel (No. 5) appears to mè to belong to the till or boulder clay; the blue clay or brick earth (No. 4) I have long regarded as a modification of that deposit, on account of its organic and mineral contents, which have originally been derived from a distance; and the brown clay, with boulders also (No. 1), certainly contains evidence of an origin identical with that of the boulder clay. The angular flints, and sandstone-boulders especially, scattered over the surface here, are similar to those of the till of the neighbouring parts of Essex. In the till, fossil remains have been found in great abundance.

"Finally, I wish to draw attention to the discovery of two extinct molluscs (*Helix ruderata* and *H. incarnata ?*) in the Copford marls—a fact of considerable importance in estimating the relative age of this deposit; and I would observe, that not the least interesting phenomenon of the Copford fresh-water beds is the superposition of an upper member of

* This also occurs in the Peat-beds of the Kennet Valley.—J. P.

the local boulder formation (bed No. 1) on the shell marl, which latter with its subjacent clays, rests on an earlier member of this formation—conditions clearly pointing out the age of the intercalated deposit. This seems to accord also with an analogous geological phenomenon in the cliffs of Eastern Norfolk and other localities, as noticed in Sir C. Lyell's 'Manual of Elementary Geology,' p. 127."

Having given these extracts from Mr. Brown's paper, I would state that I have two objects in laying this collection of the Pleistocene, or Upper Tertiary, land and fresh-water fossil shells before you. The first is, to call the attention of our young and uninitiated friends and members to the importance of a careful examination of brickfields, sand-pits, gravel-pits, and peat-beds; ugly places, truly, but by no means to be despised by geologists and fossil hunters; although spots where, doubtless, very many persons would little expect to find fossils, especially in such abundance and good state of preservation. Indeed, they would tell you they had seen numerous brickfields and gravel-pits, but never noticed any fossils in them—for this reason, because they either did *not* look, or did *not* know *how* to look, for them. As an example of my meaning, let me mention that, some time since, a gentleman who was fond of angling, complaining one day of his bad sport, was asked by me to search for shells instead of fishes. He replied, "The labour would be of little use, inasmuch as there were no specimens of the kind in the stream, except a few river muscles (*Unio* and *anodon*) at the bottom; had there been others, he was convinced he must have seen them long ago." I assured him there were plenty, and, having instructed him *how* and *where* to look, we parted. In less than a week he returned, bearing—in triumph, and astonished at his good fortune (good fortune in reality dependent upon himself)—a small box filled with living shells, amongst which was a rare variety of a species which had not hitherto fallen into my hands.

The same will apply to those persons who have visited numbers of brickfields, gravel-pits, &c., without seeing fossils. I do not imply that fossils *are* to be found in every brickfield and gravel-pit, &c.; but at the same time I must tell you that Copford is not the only brickfield from whence fossils of the character just alluded to have been procured.

Mr. Prestwich, accompanied by Mr. Brown, explored Mr. Harding's brickfield, at Fisherton, near Salisbury; where they collected, together with mammalian remains, a quantity of land and fresh-water shells, of which I was enabled to identify twenty-one species. An account of this brickfield can be seen in the "Journal of the Geological Society of London," Vol. XI., p. 101. I might mention several others of less importance.

In Mr. Hindle's gravel-pit, at West Hackney, Mr. Prestwich discovered at least twenty-three species of land and fresh-water shells; as these occurred in a rotten, and often fragmentary state, it is probable many more species may be found in the same neighbourhood. See "Journal of Geological Society of London," Vol. XI., p. 107.

In a sand-pit on Wear Farm, near the Reculvers, situated on the road from Chislet to the Reculvers, Mr. Prestwich met with a most interesting deposit, the account of which I cannot do better than recite to you in his own words, from the "Quarterly Journal of the Geological Society," for May, 1855. Vol. XI., p. 110.

"This deposit is exposed in two pits near Wear Farm (see Ordinance Map), on the road from Chislet to the Reculvers. The height of the ground above the level of the adjacent marsh, or of the sea, does not exceed 20 to 30 feet. The pit in a field to the east of the road offers the best section; it is as follows, in descending order:—1st, gravel, 3 to 8 feet; 2nd, sand, with laminated clay, 8 to 12 feet; 3rd, chalk. The shells occur principally in seams of fine gravel in the lower part of the section, where there is sand with seams of fine gravel; in a few spots only are they numerous. The greater portion of the sands and gravel are without shells. Entomostraca, however, appear to be more abundantly diffused, but still they occur chiefly in certain seams or layers.

"I found a few bones of large Mammals, some apparently belonging to the ox. The shells are in a good state of preservation, and consist of the following species, which have been examined and determined by Mr. Pickering:—

"Bithinia tentaculata, Linn.

"Ancylus fluviatilis, Müll.

"Paludina, or Rissoa; very like the one found at Grays.

"Cyrena consobrina, Caill.

"(C. trigonula, Wood).

"Opercular valves of Balanus.

"This list, although short, is of considerable interest; for here we find the Grays, or Nile Cyrena, together with two more distinctly fresh-water shells, associated with the distinctly marine genus, the Balanus. The opercular valves of this Cirriped were found in the fine gravel filling the interior of a Cyrena. The small Paludinæ and the Cyrenæ abound in places. Imperfect traces of vegetable remains occur in some thin seams of clay subordinate to the mass of sand and fine gravel. The general character of the organic remains indicates a local deposit, accumulated on the spot, and in comparatively tranquil waters.

"The fossiliferous bed is overlaid by a mass of gravel rubble and brick earth, varying in thickness from three to eight feet.

"As well as the few specimens will allow us to judge, this deposit may be correlated with the one at Clacton, on the opposite Essex coast, and will probably yield on further examination a far more important series of pleistocene fossils than those here enumerated, which were procured during two very short visits.

"Of the microscopic fossils in the deposit, the Entomostraca comprise, according to Mr. Rupert Jones, three forms—the first is very abundant, the other two very rare:—*Candona torosa*, Jones; *Cypris gibba*, Ramd., and a minute undeterminable form.

"There is also among the minute organisms picked out from these sands one rizopod—a *globulina*.

"The *Candona torosa* is a minute bivalved crustacean, inhabiting the brackish water-ditches near Gravesend. It occurs also plentifully in the Grays deposit, in company with other recent and some extinct (?) Entromostraca. *Cypris gibba* is a recent form, very common in fresh-water ponds.

"The Foraminifer (*globulina*), by its presence in the deposit in question, may be regarded as evidence of the at least brackish-water character of the Wear Farm sands. Mr. Pickering, who first discovered the recent specimens of *C. torosa* in the Gravesend ditches, found also a *Rosalina*-like Foraminifer associated with them—a parallel to the above.

"The valves of the Entomostraca are sometimes separate, sometimes united. The sand and fine gravel in which these pleistocene fossils occur, frequently contain also numerous minute chalk fossils, such as *cytherellæ*, *buliminæ*, *rosalinæ*, and *cristellariæ*," &c.

While on this subject, I cannot conclude without calling your attention to the *Peat Beds* of the Kennet Valley, in the vicinity of Newbury, Berks; from which I identified between fifty and sixty species of land and freshwater shells, collected by my friend Mr. Rupert Jones, of the Geological

Society, who has paid much attention to the geology of that district, and which were described by him in a lecture delivered to the members of the Literary and Scientific Institution, in the Mansion House, at Newbury, March, 1854; from the Appendix to which published lecture, at page 40, I will, if you please, take an extract:—

"The peat fields near Newbury, when examined, present the following series of deposits:—

"1. Alluvium, or superficial soil.

"2. Shell marl, called 'malm,' varying from one inch to eight feet in thickness, sometimes seamed with peat; occasionally wanting. On the 'marsh,' at Newbury, it is left in small hillocks, barely coated with the sward. Hard, ovoidal, concentric masses of concreted marl, of various dimensions, up to the size of a man's head, occur here and there in this deposit; generally near the present course of the river. These concretions, like the marl itself, are wholly composed of the more or less decomposed shells of fresh-water molluscs, such as *bithinia*, *limnœus*, *cyclas*, &c.

"3. Peat, varying from a thin film to more than ten feet; sometimes it is only a peaty earth, and often interrupted by seams of marl.

"4. Shell marl; argillaceous, very tough, about one or two feet thick, and very general.

"5. Gravel.

"There is more peat and less 'malm' in the Speen Mere than in Ham Marsh.

"The bones of mammalian animals have been frequently found in these peat beds, as they generally are in similar deposits. These remains are usually met with in the lower marl (4, of the above list), and apparently are more plentiful towards the edge of the valley.

"The following list comprises the best known of these fossils, from the neighbourhood of Newbury:—ancient ox, short-horned ox, roebuck, red deer, horse, boar, wolf, otter, bear, beaver, and water-rat.

"In the peat there are found:—

"Fir cones, fir bark and wood, birch bark and wood, hazel-nuts, moss, &c.; also fifty-three species of land and fresh-water shells, identified by my friend, Mr. J. Pickering, from a collection made in 1842; as well as three or more species of *cypris* (minute bivalved crustaceans), and quantities of *gyrogonites*, or the seed-vessels of the common water-plant, the *Chara*.

"Numerous miscellaneous articles belonging to the 'historic period' have been met with in the peat fields; but the exact circumstances under which they have been found, and their respective positions in the several beds, have not been carefully recorded.

"Bronze spear heads—Speen.
"Human skull—Speen.
"Clay urn—Speen.
"Iron sword—near Northcroft Lane.
"Bronze steel-yard—Thatcham.
"Iron arrow-head—Ham Marsh.
"Fragments of coarse pottery—Ham Marsh.
"Horse shoe.
"Gold pin.
"Copper ring.
"Silver ring."

Having thus dwelt upon some of the facts connected with brickfields and gravel-pits, &c., I beg to present to the Museum of this Association a typical series of the shells of the land and fresh-water mollusca of the pleistocene, or upper tertiary strata of this country; both derived from a deposit where they are more numerous, and in a more perfect state of preservation, than any that have come under my notice, and also discovered and collected by that zealous geologist, the sincere friend of, and the first benefactor to, this Association—the late Mr. John Brown, of Stanway.

The following list gives the names of these shells, the nomenclature being that of Gray's edition of Turton's Manual, 1840:—

LAND SHELLS.

1. Helix nemoralis, Linnæus	R.C.	14. Zonites radiatulus, Alder	R.C.
2. „ arbustorum „	„	15. „ nitidulus, Draparnaud	„
3. „ hispida „	C.	16. „ pygmæus „	R.R.
4. „ concinna, Jeffreys	„	17. „ crystallinus, Müller	C.
5. „ pulchella, Müller	„	18. „ cellarius „	R.C.
6. „ fulva „	R.C.	19. „ alliarius, Müller	„
7. „ rufescens, Pennant	C.	20. „ lucidus, Draparnaud	„
8. „ aculeata, Müller	„	21. Azeca tridens, Pultney	R.R.
9. „ lamellata, Jeffreys	„	22. Zua lubrica, Müller	C.
10. „ sericea, Draparnaud	R.R.	23. Pupa marginata, Draparnaud	R.C.
11. „ lapicida, Linnæus	„	24. „ umbilicata „	„
12. „ Ova of Helix	„	25. „ Anglica, Ferussac	R.R.
13. Zonites rotundatus, Müller	A.B.	26. Vertigo palustris, Turton	„
		27. „ pusilla, Müller	R.C.

LAND SHELLS (*continued*).

28. Vertigo edentula, Draparnaud R.R.
29. „ pygmæa „ R.C.
30. „ augustior, Jeffreys .. „
31. „ alpestris, Turton ....R.R.
32. „ substriata, Jeffreys .. „
33. Clausilia nigricans, Maton and Rackett ................R.C.
34. Carychium minimum, Müller A.B.
35. Acme fusca, Montagu........ „

FRESH-WATER SHELLS.

36. Succinea putris, Linnæus .... C.
37. Linnæus truncatulus, Müller „
38. „ pereger ..........R.R.

FRESH-WATER SHELLS (*continued*).

39. Linnæus palustris, Linnæus R.R.
40. Aplexus hypnorum „ „
41. Planorbis spirorbis „ C.
42. „ contortus „ R.R.
43. „ marginatus, Drap.. R.
44. „ albus, Müller ....R.R.
45. „ vortex, Linnæus .. R.
46. Bithinia tentaculata and operculum, Linnæus .... „
47. Valvata piscinalis, Müller ....R.R.
48. „ cristata „ .... „
49. Pisidium obtusale, Pfeiffer .. C.
50. „ pusillum, Turton .. „

EXPLANATION.—A.B., abundant; C., common; R.C., rather common; R.R., rather rare; R. rare.

I hope on a subsequent occasion to have the pleasure of contributing a collection of the shells from the "Grays," and some other tertiary formations; trusting, in the interim, that some of our members, who feel interested in tertiary fossils, will neither shut their eyes nor look in the wrong direction, when in the vicinity of brickfields, sand or gravel-pits; where, if the men are at work, it will be found that the price of a pint or two of beer, if judiciously bestowed, will often produce great results. I trust also that those gentlemen, when successful, will not forget this Association, but will favour their brother members with some account of their explorations and a sight of their findings.

A discussion followed the reading of the paper, in which the President, Professor Tennant, Mr. Prestwich, Mr. Wetherell, Mr. Cumming, and other gentlemen took part.

Annual General Meeting, Monday, January 7th, 1861.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The Secretary read the Annual Report of the Committee, as follows:—

REPORT.

The Committee of the Geologists' Association, whilst presenting their Second Annual Report, have great pleasure in congratulating the meeting upon the continued success and prosperity of the Society; and in stating, that although some members have withdrawn during the last twelve months, from the pressure of business and various causes, the accession of new names has caused little alteration in the receipts.

During the past year, a series of excursions to places of geological interest was commenced—Folkestone, Maidstone, and Charlton being visited. As these excursions gave great satisfaction to the members, it is intended to follow the same course, and to again hold two or three field lectures before the close of the present session—of these timely notice will be given.

The Committee are glad to find that the appeal which they lately made to members, requesting such gentleman who had time and opportunity to prepare papers for the Association, has not been in vain. Several papers have already been promised, or sent; but the Committee would again urge upon members that it is very desirable that such as are able should forward communications to the Secretary, since it is by reading and discussing such communications at the meetings, that the objects for which the Association was formed may be best promoted. Several donations of fossils have been made to the Association, and the Committee especially call attention to the fine collection of shells from the Upper Tertiaries in Essex, which has been presented by Mr. Pickering. As the fossils belonging to the Association will shortly be arranged, it is hoped that the collection, though at present small, will be of such a character as to form a nucleus from which, eventually, a good typical collection may be produced.

With a view to the formation of a library, the Committe propose spending £5 on good geological works, which will be laid before the February meeting; and they would invite contributions of books relating to the subject, from any members who may happen to have duplicates in their possession.

The Committee have found difficulties in carrying out successfully a system of exchange of specimens amongst the members, both on account of the small number wishing to avail themselves of the advantage, and of the different values which the person receiving and the person taking put upon the same specimen. The Secretary, who has not received above five or six letters upon the matter during the year, has placed the parties wishing to exchange fossils in communication with one another.

At the close of the past session, it was stated that the rooms might possibly be changed; but the Committee having entered into new arrangements with the College of Dentists, respecting the occupation of the rooms heretofore occupied by them, will continue to hold, as before, their evening meetings on the first Monday of the month, at 5, Cavendish Square.

The legacy left to the Association by the late Mr. Brown, of Stanway, has, together with a sum of £20 arising from life subscriptions, been invested in the purchase of £126 16s. 4d., £3 per cent. Consolidated Bank Annuities.

The following papers have been read during the session:—

"On some Fossil Remains of Mammalia, lately discovered in Essex, with Remarks on the Position of the Beds of Drift in that County, and in the County of Suffolk." By the late J. Brown, Esq., F.G.S.

"On the Theory of a Gradual Withdrawal of Heat from the Earth, as Explanatory of certain Geological Phenomena." By J. Curry, Esq.

"On the Geology of Whitecliff Bay, Isle of Wight." By Mr. Mark Norman.

"On a Stalactite found in Flagstone Rock, at Haslingden, near Manchester." By the Rev. L. H. Mordacque.

"On the Crag." By E. Charlesworth, Esq., F.G.S.

"On the Action of Heat on certain Sandstones of Yorkshire." By C. Tomlinson, Esq.

"On the Flint Implements lately found in the Drift." By S. J. Mackie, Esq., F.G.S.

"On the Kentish Ragstone, as exhibited in the Iguanodon Quarry at Maidstone." By W. H. Bensted, Esq.

"On the Mastoid Appearances exhibited on the Faced Flints employed for the Outer Walls of Buildings." By C. B. Rose, Esq., F.G.S.

"On the Application of Crystallography to Mineralogy and Geology." By the Rev. W. Mitchell, M.A.

"On a New Red Sandstone Quarry at Stourton, in Cheshire." By J. H. Mitchener, Esq.

"On Brickfields, Gravel Pits, and Peat Beds at Copford, Fisherton, West Hackney, Reculvers, and Kennet Valley." By J. Pickering, Esq.

In conclusion, the Committee beg to recommend the following list of Officers for 1861:—

PRESIDENT.

The Rev. Thomas Wiltshire, M.A., F.G.S., &c.

VICE-PRESIDENTS.

J. Pickering, Esq.
Toulmin Smith, Esq.
Professor J. Tennant, F.G.S., &c.
Charles Woodward, Esq., F.R.S., &c.

TREASURER.

William Hislop, Esq., F.R.A.S., &c.

GENERAL COMMITTEE.

A. Bathurst, Esq., B.C.L., &c.
A. Bott, Esq.
E. Cresy, Esq.
J. Cumming, Esq.
R. Farmer, Esq., F.G.S.
H. S. Kempton, Esq.
J. Le Cappelain, M.M.S., &c.
Thomas Lovick, Esq.
S. J. Mackie, Esq., F.G.S., &c.
B. Marriott, Esq.
W. T. Rickard, Esq., F.C.S., &c.
J. E. Saunders, Esq., F.G.S.

HONORARY SECRETARY.

W. N. Lawson, Esq., M.A., &c.

The President having explained that the adoption of the Report would carry the election of the officers recommended therein, it was moved by Mr. Brain, seconded by Mr. Collingwood, and resolved unanimously, that the Report be adopted.

The following Balance Sheet was then submitted, signed by the Auditors:—

GEOLOGISTS' ASSOCIATION.

Account of Receipts and Disbursements for the year 1860.

	£	s.	d.		£	s.	d.
Balance from 1859	44	11	9	Printing, &c.	24	16	6
By Subscriptions	79	8	9	Postage, Advertisements, Stationery, &c.	10	18	3
„ Life Subscriptions	3	3	0	Rent	25	0	0
„ Mr. Brown's Legacy	99	19	0	Attendance, firing, &c.	8	16	0
In Secretary's hands	0	14	8	Photographs—printing and mounting	5	9	8
				Purchase of Stock	120	3	6
					195	3	11
				Balance in Treasurer's hands	32	13	3
	£227	17	2		£227	17	2

We have this day examined the account of the Treasurer of this Association, and find a balance of £32 13s. 3d. in his hands.

(Signed) J. CUMMING.
R. FARMER.

Jan. 5th, 1861.

Ordinary Meeting, Monday, Jan. 7th, 1861.

The Rev. Thos. Wiltshire, M.A., F.G.S., in the chair.

The following gentlemen were elected members of the Association:—J. H. Bailey, Esq.; W. Bollaest, Esq., F.G.S.; W. H. Cooke, Esq.; and Dr. Lister, F.G.S.

The following papers were read:—

1.—"On the Geology of the Island of Sheppey." By the Rev. R. Bingham, M.A., Incumbent of Queenborough.

The strata of Sheppey belong to the series of the London basin, of which the island itself is an *outlyer*, having been split off and pushed away to the northward aud eastward; its southern side being depressed in proportion as its northern coast is elevated, some 200 feet in the highest parts, above the level of the sea. These strata were undoubtedly formed below the waters of the eocene period of our theory, though now raised high above the ocean. Yet for many a long year the envious waves have been clamouring again for their own, and are ever and anon triumphantly carrying back their annual spoils by the attrition and detrition of the cliffs; the land-springs at the same time co-operating, and sometimes causing immense slips, as at Warden, about 18 months ago;* and at the same place, a little more to the eastward, very recently.

Sic omnia fatis
In pejus ruere et retro sublapsa referri.

The tertiary beds are divided by some geologists into four groups, viz., *the crag formation*, about fifty feet in thickness, so well developed in the

* The following account of this remarkable land slip is extracted from a local paper:—

The Land Slip at Warden Point.—The following letter on the above subject will be read with interest by some of our own readers, but more especially by those who study the physical construction of the island and its geological formation:—

"The whole northern sea board of the Isle of Sheppey, from near Mile Town, east of Sheerness, to Warden Point (from whence eastward the land rapidly falls, and the cliffs terminate towards Shellness point at the eastern entrance of the Swale), is composed of London clay, of undulating form, moderate height, and intersected by a few main gullies or chines, carrying off the surface water. The eastern parts of Norfolk; *the upper marine*, or *Bagshot sand*, so named from the chief town of the locality where it may best be studied, from 100 to 200 feet in depth; the *fresh-water formation*, which ranges perhaps from 100 to 150 feet; and *the lower tertiary*, from 400 to 550 feet in thickness. Other writers have made a threefold division, and have preferred the rather awkward names of *pliocene*, *miocene*, and *eocene*, from

whole of this cliff is constantly falling, acted upon by atmospheric agencies, the influence of the tide and waves, with gales from north-east, and from land drainage, forming a sloping undercliff below.

"There are, however, some exceptional circumstances about this fall, which the agencies above referred to can apparently hardly account for; and the following slight sketch may possibly draw towards it the attention of others who have made such subjects their more especial study, and may not be wholly uninteresting to the general reader.

"About three years back a similar fall or slip took place to the westward, which the present one in effect appears a continuation or prolongation of to the eastward. The present fall is immediately adjoining the church, extending an equal distance east and west of it, including about two and a half acres of land, the former fall apparently about three times that amount; in all there are some ten acres of land affected, and in each case the results are similar. The recent fall took place on Sunday, the 11th inst., about 9 p.m., and occupied some hours—*i.e.*, it was a gradual, and not a sudden movement or subsidence.

"The results presented are these. A broad belt of land moves seaward (not a mere abrasion or undermining of the cliff), settles vertically downwards, or spreads out and slides seawards, presenting a new cliff landward at the last parallel fissure; and the moving mass obtains a state of rest in the form of an undercliff. This latter presents the following appearances:—The mass in moving appears to fall forwards towards the sea into regularly defined parallel belts of, say, ten feet in thickness; these laminæ, as it were, obtain a state of rest at an angle inclining forwards of about 45 deg., so that the fallen mass now presents in the valley of the fall a series of parallel terraces rising and falling in steps, the faces composed of the fresh section of the natural clay, the tops dipping towards the sea, the turf and vegetation undisturbed. The mass, in subsiding or falling forwards, is split into layers presenting angular sectional edges, or leaning stacks of tiles or slates. The mass is more broken up, and rises into a huge mound seaward, so that the fall assumes a concave or valley form beneath the cliff, falling from it and then rising again seaward. An extraordinary result of this fall is that it has, by its superincumbent weight, driven the old foreshore and superimposed shingle up about ten feet above its former level, rounded in form. My attention was specially directed to this result, which is apparent when standing on the shore. The fall is, in fact, a complete avalanche of earth intersected by parallel fissures or crevices, scooping up and causing the saturated material forming the foreshore to rise up *en masse*. The singularity, as many observed looking on, was, that this great slip should have occurred after so dry a season. The edge of the altered cliff is now only eighteen yards from the chancel of the certain Greek words; * and meaning, in our mother tongue, *more recent*, *less recent*, and *the earliest* or *dawn of the recent*. I believe, too, *pleistocene*,† *most recent*, has been applied to the crag formation.‡

We now understand what is meant by *the lower tertiary* or *eocene beds*, consisting of the London clay with the plastic clay and associated sands underlying it, as developed at Sittingbourne and Higham, at Erith and Blackheath.

In Sheppey, those sands of the lower eocene are at a great depth beneath our feet, but are penetrated by the artesian wells, which pierce the plastic and its subalterns, and so tap the natural tank in the hollow of the basin of chalk. Of the London clay itself (so called, by the way, because it forms *the substratum of our great metropolis*), we could know but little in Sheppey, and not at all possess ourselves of its *fossils*, did it not rise and crop out on the northern side for a range of about five miles. In technical language, this is a splendid *escarpment*. The clay itself is of a dark blue or bluish black complexion, forms a most intractable soil, and, when soaked with wet, is obstinately and provokingly adhesive, clinging most pertinaciously to one's heels; as your unworthy lecturer has sometimes experienced to his great disgust, when rambling along shore, or climbing among the ruins and *detritus*|| of the cliffs, in search of their disembowelled treasures.

church, in a line with the west side of the nave, and portions of the row of trees and fence adjoining have settled down bodily, and are now standing on the under-cliff, some fifty feet lower than they were when *in situ*, at a slight inclination, corresponding with that of the detached pieces of cliff on which they stand, plainly denoting how gradual and vertical has been the subsidence.

"It is difficult to account for this phenomenon; a question arises, viz., to what extent are the bases of cliffs in the tertiary formations saturated or affected by percolation through fissures by tidal agency, and how far may this be the first cause?

"There are no appearances of land springs from the cliff-face; the whole appears to have squeezed down into a saturated or partly fluid base, or this apparent effect may be the resultant merely of the spreading of the dislocated mass.

"I am, sir, your obedient servant,

"Sept. 21, 1859. "J. B. Redman."

* Πλεῖον, *more*; *μεῖον*, *less*; *ἠὼς*, *the dawn*; and *καινὸς*, *new* or *recent*.

† Πλεῖστον, *most*, and *καινός*.

‡ This is a local term in Norfolk and Suffolk for a deposit of gravels and sands.

|| From *detritum*, the supine of *detero*. It means the disintegrated materials of rocks.

In some places the characteristic clay is intermingled with ferruginous and green-coloured sand, and is generally capped with yellow gravelly or sandy marl from a yard to six or seven feet in thickness. The stratum itself abounds with the *septaria*, to be presently described; with *selenite*, *wood* fossilized or perforated by the *teredo* who has left his sheath behind him; the fruit of the nipa palm, provincially called *figs* by the along-shore-men; innumerable specimens of seed-vessels, berries, and fruits, and stems of *aromatic shrubs*, all of a tropical character; and some of the species indigenous in Sumatra, and that part of the world. Among them are very many varieties of *marine* and some *lacustrine shells*, also tropical. We meet with the remains of *fishes*, the teeth and vertebræ of *sharks*, mingled with traces of the *crocodile* and the *boa constrictor*, * as well as the remains of a peculiar kind of vulture, the *lithornis vulturinus*; † with examples of the *nautilus*, the *turtle*, and a large kind of *tortoise*, besides varieties of *crabs*, and the remains of *lobsters* and other crustaceans. The vestiges of *elephants* ‡ have also been discovered in Sheppey, and I

* The writer of "A Leaf from the Oldest of Books" in *Household Words*, for June 20th, 1856, tells us that in February of that year, he obtained of a person named Pead, at Hensbrook, in Sheppey, two good portions of the *vertebræ of the boa constrictor* of the eocene period, the *palæophis toliapicus*, *i. e.*, the *pestle like old serpent*. One of these specimens included thirteen *vertebræ* retaining their manifold and complex articulations, and must have belonged to a serpent some fifteen feet in length.

† The same authority states, that this specimen was obtained at a cottage near Warden, as well as a portion of the jaw, with teeth, and two *vertebræ* of that remarkable quadruped, somewhat between a modern hog and a hippopotamus, which Professor Owen has named the *hyrcotherium*.

‡ In the year 1750, Mr. Jacob, of Faversham, discovered in this parish the *acetabulum* of an elephant sticking in the clay, which was partly washed away from the cliff; and at the same time other parts of one; as one of the spinal *vertebræ*, a thigh bone four feet long, and numerous other fragments, too rotten to be taken up entire. Some time after which, on a further search, he found an elephant's tusk, and as it lay entire to appearance, took its dimensions, which were in length eight feet, and in circumference in the middle twelve inches; but it fell to pieces in endeavouring to raise it.

He also found part of a *scapula*, its fins almost entire, and three inches diameter, and some pieces of the grinders; and a large one at a another time, in a different part of the island. The *pyrites*, however, abounded so much in the clay wherein these bones were embedded, that it prevented their being found in a tolerable perfect state; but these fragments were sufficient to show that this elephant was as large as that mentioned by *Fentzelius*, in the Philosophical Transactions. Mr. Jacob's account of the discovery was published in the above-named Transactions, vol. xlviii., part ii., page 626.—See *Turmine's Rambles in the Isle of Sheppey*. London, 1843.

have seen in Dr. Bowerbank's private museum the toe-bone of a pachyderm, which must have been about eighteen feet high* in proportion to the length of that bone from the mammoth's foot.

Dr. Bowerbank also possesses a colossal tortoise, which he obtained a few years ago from the same locality. The dimensions are over eighteen inches by twelve; and the thickness considerable.†

Most of these organic remains, excepting, of course, such as consist of phosphate of lime (as, for example, the fossil crabs and other crustaceans), are highly *pyritous*, especially the seed-vessels, the fruits and stems and bits of wood, as well as most of the shells; and consequently, having been converted into *sulphuret of iron*, they rapidly decay when exposed to the action of the atmosphere.‡ "So that," as the late Dr. Mantell elegantly observes, "the collector often finds the choicest *fossil* fruits in his cabinet, like the fabled apples of the Dead Sea, one moment perfect and brilliant, and the next decomposed and changed to dust, leaving only an efflorescent sulphate (sulphuret or salt) of iron."

It will be useful to describe *seriatim* the most important of these numerous illustrations of the palæontology of Sheppey.

1. The *septaria* varies in shape, but it may be generally described as *a spheroidal nodule of argillaceous limestone*, sometimes almost as globular as a cannon-ball, ‖ but frequently oval, oblong, or quite tabular. In what I term *the true septaria*, the *septa*, whence the name, that is *the diagonal* or *irregular divisions* right through the body of the mass, are, in fact, thin walls of calcareous spar or crystallized sulphate of barytes, of a bright deep yellow colour, which fades after exposure to the light; while the action of the atmosphere seems to neutralize in some degree the peculiar

* Is it not probable that this tarsal bone belongs to the vestiges described in the preceding note?

† This curious specimen is described more in detail towards the close of this paper, at p. 104.

‡ It is a very good plan, after soaking the *fossil* in soft water and drying it thoroughly in the sun, to coat it over with a thin solution of common glue. This method greatly helps its preservation.

‖ A large nautilus is often the nucleus of this kind to which the term *septaria* is not so strictly applicable, for they have no diagonal or vertical *septa* in them; though being divided, they often reveal the chambers of the nautilus. This kind of cement stone, the most valuable of all, is now chiefly collected at Harwich. Some specimens very much resemble the bodies of turtles and tortoises.

properties of the mineral. For this reason, those nodules are the most valuable for converting into cement which are gathered up shortly after their separation from the cliff. Still more valuable are the masses which are dug up at low water from beneath the clay forming the *scars*, as the term is at Whitby, in front of the cliffs and to seaward; or they are dredged up from the bottom beyond low water-mark. Thus the cement-stones are procured in three ways: on the beach, as they are washed out from the ruins of the escarpment; or pricked for in the mud and exhumed; or gathered by the fisherman's dredge, when he has no more profitable work. The collections, often containing valuable specimens of *nautilus*, are piled in heaps on the flats, where they are distinguished by little beacons planted on them, till removed in barges to the factories at Thames Bank, Elmley on the Island, or elsewhere. The *septaria* from the middle and lower part of the London clay yields the best cement. But the nautilus is the most valuable; just as the *dogger*, that is, the fossil ammonite from the scars of Whitby and the neighbourhood, is prized on the coast of Yorkshire, where it abounds in the lias.

The *septaria* is found in other beds of clay besides the London; for example, *the Kimmeridge*,* so amply developed in the neighbourhood of Weymouth,—the colour of the stone varying in accordance with the peculiarities of its native bed. The *septariæ*, however, of the Kimmeridge are generally more tabular and much harder than those of Sheppey, especially those which are so plentiful in the upper strata of the bed; so much so, that they can be cut into slabs, and are capable of a high polish, forming beautiful tops for small ornamental tables. Some of the Sheppey specimens are very *pyritous*,† particularly those nodules of which the nautilus or some other chambered shell was the foundation.

Indeed, is it not probable that some mollusc or jelly-fish originally formed the nucleus of every *septaria*, and that the *septa* were produced

* So termed from Kimmeridge, a village of the Isle of Purbeck. The Kimmeridge clay is an argillaceous deposit from the upper oolite.

† A very beautiful and peculiar crystal is sometimes met with on a *septaria*, first noticed by Mr. Higgins and a friend, during a ramble in Sheppey, in 1830. At first it was supposed to be nitrate of potash, but it was subsequently proved by a series of experiments to be chloride of carbon. A full description of this curious substance, though written at the time, was not published till 1842, in Mr. Higgins's "Book of Geology," where an appendix is devoted to the topic. See p. 358. London: Tyas, Paternoster Row. 1842.

after the creature was perhaps suddenly enveloped in soft or semi-liquid clay, by gases evolved from the decomposing animal matter, causing the conglomerate to crack in virtual lines, till, other chemical changes taking place, the chinks became filled with calcareous spar, often bespangled with crystals of pyrites; and the result has been a substance profitable for commerce, ornamental in the drawing-room, or illustrative in the cabinet? A chemist with whom I am acquainted, and to whom I once mentioned my theory, called it "an ingenious solution;" but added that, "as *a chemist,* he should not like to subscribe to it." "The difficulty is," said my friend, "that the animal matter should have remained intact until the *septaria* was fully formed. This must have taken many years, while the animal matter would have totally changed its character, and ceased to disengage gas in the course of a few weeks." Now, that is in fact my case. I conceive the *septariæ* to have been formed by some sudden convulsion and rapid chemical operation, as probably the flints were in the laboratory of nature, in the pre-Adamite ages: and that, supposing animal matter to have evolved itself in a few weeks, as speedily were the cracks and crannies I have been speaking of filled with sulphate of barytes.* Else, how is it that the chambers of the nautilus are found filled with spar or metallic matter, and the *choanite* infiltrated with chalcedony? However, let this little *lis* remain for a while *sub judice;* and allow my theory, at any rate, to amuse, till an abler head demonstrates a better.

I mentioned just now that *septariæ* become less valuable for mercantile purposes when broken into small fragments, and exposed to the action of the atmosphere on the internal surfaces. For this reason, the labourers employed in collecting the cement-stone are very jealous of a visitor who may be so imprudent as to carry openly in his hand a geological hammer, or be observed now and then rapping these wonderful nodules. We ourselves were once exposed to no little annoyance and rough language in this way, while rambling at the foot of the cliffs. From want of the bump of caution counterbalancing the bump of inquisitiveness, or through defective training in the circumlocution office, we were cracking the *septariæ* here and there, certainly intending no harm to the lord of the manor or any other mortal being; but we were rudely interrupted by the

* *Baryum,* from *βαρὺς, barys, heavy,* is one of the elementary principles, with an alkalifiable base.

along-shore-men, and found that argument and reasoning on our part were of no avail to convince them that—

> "If offending aught,
> The love we bore to learning was in fault."

However, the *argumentum ad hominem*, in the shape of the purchase of a fossilized crab or sea-spider, without asking for change out of the shilling or florin thus wisely spent, was the best method of disarming the jealousy and appeasing the wrath of these hard-working fellows, always so ready to drink a stranger's health, and to take care that an amateur geologist does not walk over *their* ground without paying his footing.

2. *Selenite*, or crystallized gypsum, that is, sulphate of lime, so common in the Oxford clay of the secondary series, and called *quarry-glass** by the country people in the neighbourhood of Shotover (where I first studied the mineral and learnt the A B C of my geology), is found in great abundance in the London clay of Sheppey, especially at the cliffs of Minster and Eastchurch. I have not met with it so plentifully at Warden. The pieces to be gathered on the shore are unfit for the cabinet, having been rubbed and rounded by the action of the waves. But matchless specimens may often be taken from the surface of the *debris*, especially after recent land-slips, or in spots where the springs ooze out, or little rills come trickling down. There are several varieties. Some of the most elegant are like thick but transparent tapering leaves, foliating as it were from a central stem, with fibres branching right and left,—the *laminæ* of the crystal are so beautifully placed. Others resemble prisms of glass, while many assume the shape of fantastic globules of angular irregular masses, radiating from a common centre. These varieties are in some spots so abundant, that a barrow-full might be collected in half an hour.

3. The Sheppey Cliffs are most prolific in iron *pyrites*,† provincially

* The name *selenite* is borrowed from the Greek σελήνη, *the moon*. Dioscorides uses the term σεληνίτης λίθος, *a moon-stone*, or *stone from or like the moon*. The term arose, as did *pyrites*, *barytes*, &c., from misapprehension as to the real nature of the mineral, respectively. It would now be well to abandon the misnomer, and say, *crystallized gypsum*.

† That is, *fire-stone*, from the Greek word πῦρ, *fire*. The term was originally applied to this mineral, long before its real nature was understood, on account of its sulphury smell. The globular specimens, so often met with in the chalk, are vulgarly called *thunderbolts*, from the ignorant supposition that they are shot into the ground at every flash of lightning.

termed *copperas stone*, but improperly so, for there is no copper whatever present; it is a combination of sulphur and iron, and is, technically speaking, *a sulphuret of iron*. By exposure to the air and roasting the iron attracts oxygen from the atmosphere, and becomes oxydized, setting the sulphur free. This may be either sublimed, or be made to unite with oxygen gas, and so form vitriol or sulphuric acid. The sulphate of iron is manufactured at Queenborough,* from the pyrites of the cliffs, by another process which it belongs not to this kind of lecture to detail.

The Sheppey development of the eocene beds is rich in this mineral, to an amount far exceeding all other classes of its organic remains put together, and the variety of *configuration* is endless. Some specimens are smooth and round, or oblong; others are flattened, or covered with excrescences, or are crooked and twisted into funny and fantastic shapes. Pieces of wood, stems of shrubs, cocoa-nut shell, fruits, seed-vessels of aromatic plants, a kind of coffee bean, berries and capsules, vertebræ of fish and bones of animals, with *turritellæ, buccina, cypræeæ*, and many other shells, have been made pyritous, or been converted into pure pyrites. Innumerable specimens, and many of them very perfect and beautiful, will often be observed when the tide has ebbed, especially when the wind is from the southward, lying in ample profusion in little sandy drifts and patches of fine gravel on the shore, at spots free from the incumbrance of the rougher shingle; from such favourable places I have occasionally selected the most delicate and elegant branching stems, with the knots and processes of the boughs admirably distinct.

Among *the fossil-fruits* † we may meet with petrifactions closely resembling dates, figs, mangoes, and the nut of the nipa genus of the palm; whose congener abounds at this day, as I have hinted before, in the Moluccas and Philippines, and other islands of the great eastern archipelago. I once thought I had picked up a perfect capsicum, as well as a veritable lemon, or genuine citron; but a gentleman, who is a coryphæus in such matters, pronounces my prizes to be mere *lusus naturæ*, under the category of fantastic pyrites; and of course I must believe him, for geologists, like bankers, never make an error in their books!

But to return, so endless are the real specimens, particularly to the eastward, in the neighbourhood of Hensbrook and Warden Point, that we

* At the works of Mr. Josiah Hall.

† See Dr. Bowerbank's memoir on "The Fossil Fruits of the London Clay."

may reasonably suppose, with Dr. Mantell, "that a group of spice islands, such as those of our modern eastern archipelago, must once have existed in the regions now forming the gulf of the London basin, at some epoch antecedent to the creation of mankind; otherwise it would be difficult to account for such an accumulation of vegetable productions. The seed-vessels," continues that eminent geologist, "are referable to several hundred species, including the cardamom, the date, the areca, the cocoa, and one kind of berry bearing much resemblance to the fruit of the coffee." Thus my statements are confirmed by first-class and unimpeachable authority.

4. The *fossilized wood* associated with the beds we are describing is, for the most part, of a deeply dark colour. In many specimens the ligneous fibres and circles of growth are well defined; some kinds are beautifully veined with brilliant pyrites, or the fissures are found filled up with metallic matter, and the petrified block is consequently capable of a very high polish. I have seen slabs of fossilized wood cut horizontally from the heart of large trunks, which were truly noble specimens. These blocks are entirely exempt from the ravages of the borer, and must have been speedily buried; whereas numerous masses of the fossil wood of Sheppey have been perforated by that mischievous, though industrious, little creature. Many pieces of fossil wood are pierced and pervaded in every conceivable direction; often the fibres of the vegetable have been completely eaten out, and nothing left but the intricate convolutions of the worm, though the form of the original trunk is not lost, the busy animal, with its auger-like beak, having left not only its sheath* behind, but sometimes its own body, in a metamorphosed condition. Now and then the tubular cases, or *thecæ*, of this submarine workman are hollow, but as often are they filled with pyrites, or indurated clay, or argillaceous limestone, or calcareous spar. The polished sections of these varieties exhibit very prettily the meandering groves of the ancient tenant. The species developed in the Sheppey wood is nearly identical with the *teredo navalis* of the West Indies. By the way, another weight *this* in the scale of the opinion that the spot now called *Great Britain* was at some remote period a district as warm, and as richly clothed, as are now the tropical regions of our era.

* Or its shield, as some have termed it. This furnished Mr. Brunel with the idea of the sheath, or shield, used in the formation of the Thames Tunnel.

5. It is not difficult to find innumerable *fossil shells*, also referable to very many species, whether univalve, bivalve, or multilocular and chambered; not, indeed, in the face of the cliff, close under which it is not very safe to pass where the escarpment is perpendicular, but rather among the *debris* on the shore. Indeed, most of these specimens are not so much disintegrated from the face of the cliff as washed up with the abrasion of the scar by the action of the waves, especially in those places which are covered by the tide at high water. It is not easy, however, to meet with specimens of the larger sort on the shore itself, for everything of that kind is quickly picked up by the copperas and cement stone collectors* in their daily walks. Yet, even with your own hands, you may gather specimens of the *teeth*, the *palatal bones*, and the *vertebræ* of sharks and large fishes, as well as the heads, gills, and scales of the finny tribe; many of which are very curious and interesting, and will amply reward the man who searches for them with his own eyes and *con amore*.

My own diligence has been rewarded by some perfect teeth, the *vertebræ of a snake* known by the ball and socket joint, a coffee bean, a most delicate specimen of the *turritella*, a *veritable crab* which I captured *in situ* from the breast of the cliff, and some incomparable fruits and stems; to say nothing of a host of items well worthy of the cabinet of an

* They dispose of their findings chiefly to a peripatetic dealer in fossils, well known at Sheerness by the name of Paddy Hays, who inhabits a small tenement in one of the narrow back streets of Blue Town. Hays is a very civil and well-disposed man, and, though wholly ignorant of the science of geology, can give the inquiring tourist some useful information of the practical kind. "Let no one," says the writer of "A Leaf from the Oldest of Books," "who visits Sheppey for the sake of its fossils, lose a moment after his arrival at the Royal Hotel, or the Wellington, in requesting the attendance of the industrious collector and humorous vendor of the natural curiosities of the neighbourhood, who is best known to the servants of these inns by the name above cited. Mr. Hays will submit to you, with, perhaps, one or two exceptional *rarissima*, reserved for old scientific customers, all the best fossils which he has been able to collect since his boxes were emptied at the last visit of the curious. He will expatiate upon them in a language combining a fragmentary assortment of learned technicalities with the richest of brogues; but he will not ask much more than the market value of the fossils, and a very little bargaining will leave a characteristic assortment of fossil fruits, fishes' heads and trunks, teeth of sharks, teeth and bones of crocodiles and turtles, outlandish petrified crab-like and lobster-like crustacea, the nautilus and other eocene shells, in the possession of the *dilettante* visitor, at a very moderate cost."—See Dickens' *Household Words*, for June 7, 1856.

humble amateur. But, verily, if you wish to collect, I would rather say *select*, your own specimens, you must often go down on your bended knees, or submit to many a back-ache, while you pore over the little sandy drifts I have already mentioned, or rummage in small pools of water under the lee of big stones; or scratch into the muddified silt, where some tiny brook issues from a ravine in the cliff, and spreading out over the beach for many a yard, frets its fidgetty passage to the tide. These shallow or superficial watercourses are rich with seed vessels, fruit, berries, and stems, intermingled with shells and other spoils belonging to the smaller examples. These trophies will amply repay the collector for his trouble.

The species of the smaller shells are far too numerous to be particularized, or very accurately described in a brief treatise such as this is; suffice it to say, the *trochus*, *buccinum*, *turbo*, and a minute bivalve of the oyster tribe are most common. But among the smaller illustrations of univalves, of which I am now more particularly speaking, I have noticed a *fusus* similar to that of the Paris basin, a kind of *cerithium*, and a species of *pleurotoma*. I have not met with the *pelican's foot* in Sheppey, which is frequent in the plastic clay of the Southampton basin, and I have specimens from the neighbourhood of Portsdown Hill to the westward and southward of Fareham.* They are very beautiful, and the angles, points, and marks are as sharp and distinct as they were when first imbedded in the soft clay which enveloped them, perhaps some tens of thousands of years ago.

6. The chambered shells are limited to the species *nautilus imperialis*.† Very excellent specimens of this fossil are pretty readily obtained, especially from the men who collect the cement stone, who frequently exhume the mass from under the clay at low water, when searching for *septariæ*, as described before. My own little cabinet rejoices in two or three

* The specimens alluded to came from the bed of plastic clay cut through during the formation of the Fareham tunnel on the branch of the South Western Railway, which unites Bishop's Stoke and Gosport. From the same source I procured some beautiful examples of *cardium*, *pinna*, &c., together with wood penetrated by a very small kind of teredo. None of these specimens were pyritous, the plastic clay of the region referred to being destitute of sulphur and iron.

† Also from the Greek, *ναυτίλος*, *a sailor*, termed *ποντίλος* by Aristotle.

samples, one of which is a good deal bespangled with crystals of pyrites, while the other retains much of its pearly lining in native freshness; its chambers, too, are coated with calcareous spar, and the interstices filled with argillaceous limestone.

7. Among the *fossil crustaceans* which enhance the wonders of Sheppey are two small species of crabs, of which the spider-crab is the rarer sort; also the lobster, which is seldom found entire; the *chelonite*,* especially the kind allied to the recent *emys*, † or tortoise, or fresh-water turtle, the carapaces of which are not uncommon. Some examples are magnificent. "On the present occasion," writes a visitor to Sheppey, for geological purposes, I quote from Dickens' *Household Words*, for June 7, 1856, "I had the good fortune to meet with a large *chelonite*......It is now the prime ornament of my tertiary cabinet, and is allowed to be the finest example of a *terrapene* or fresh-water tortoise that has yet been got. The true turtles are much more common on Sheppey. My fossil terrapene equals the largest known living species, and exceeds by more than four times the solitary species of *emys* that still lingers on the European continent. It will be the subject of two beautiful plates in the forthcoming number of Owen's 'History of British Fossil Reptiles,' and has gladdened the eyes of the professor by a more exact demonstration of all the complex sutures of carapace and plastron, and by more perfect impressions of all the tortoise-shell plates that of old covered the now petrified bony box of the slow-treading reptile, than the anatomist had previously witnessed in any fossil tortoise or turtle." Such a prize even Dr. Bowerbank had to purchase of a labouring man named Crockford. The tourist can scarcely hope to meet with such a treasure in his casual and hasty walk along the shore. These wonders of our science are at once secured by the workmen on the beach, as I have already explained, who are daily at their business between tide and tide. The best crabs, too, are purchased of the same people, or their wives, who gather up the copperas while the men get the cement stone. But should *mon ami* really wish to catch a veritable crab with his own hands, he may, perchance, now and then succeed in doing

* From χελώνη, a *tortoise*. Any tortoise-like fossil is a *chelonite*.

† Properly the *water tortoise*, or *fresh-water turtle*, as coming from ἐμύς. Specimens of this kind are common in the Wealden of Tilgate Forest in Sussex.—See *Mantell's Wonders of Geology*, sect. 4, sect. 52.

so, and without getting his fingers nipped, the creatures having for millenaries ceased to bite; but not without the risk of being ankle deep in mud and mire, while scrambling among the fallen masses of the clay. On one occasion I was, myself, so fortunate as to accomplish this, and picked with my own right hand a fossil crab from a projecting mass on the precipice! I was rambling slowly along, like Æneas in search of the golden bough, and had just thought within myself, as the son of Anchises is said to have done, while wandering in the woods of Aornos,—

"Si nunc se nobis ille aureus arbore ramus
Ostendat nemore in tanto!"
"Oh! in this ample grove, could I behold
The tree that blooms with vegetable gold!"
DRYDEN.

Yes, so thought I; and looking up meanwhile, I caught sight of the coveted fossil, in a most convenient and inviting position, just above my head, but within reach. I clutched it, and it instantly yielded to my grasp; while I verified in my own experience the Sibyl's prophecy, as the said Trojan hero found it true:—

"Ipse volens facilisque sequetur
Si te fata vocant."
"Thy purpos'd journey if the fates allow,
Free to thy touch shall bend the costly bough." DRYDEN.

Let me, however, just mention that it is not safe to approach these tottering walls too incautiously. They are perpetually coming down in masses, though small comparatively, yet large and heavy enough to bury a man in a moment. Not so long ago, a workman had deposited his coat, and a satchel containing his dinner, beneath the cliff; five minutes afterwards down came a slip of several tons, and providentially overwhelmed the coat, instead of inhuming its owner! Certainly, if the same kind of thing were to happen to you, you would escape the humiliation of becoming food for these crabs; but it would not be very pleasant to find yourself buried in their midst, if not fossilized among them.

Many of these *carcinites*, as we might justly term them,*—for we say *chelonite*, *scaphite*, and *belemnite*,†—are so complete or so little altered, that

* From *καρκίνος*, *a crab*.

† From *σκάφη*, *a little boat* or *skiff*, and *βέλεμνον*, *an arrow head* or *point of a dart*.

a child might easily discern them. I have myself handled one with the point of a claw so sharp that it almost pricked the finger. Many, again, are more or less water-worn and defective; while others have little more than a portion of the carapace or the traces of a single claw remaining. Numbers retain nothing but the type of configuration. In fact, the beach abounds with multitudes of oblong, kidney-shaped pebbles,—*carcinoids* may I call them,—of which, possibly, the neuclei were crabs, strange as that may sound; although to the untutored gaze of the general visitor these stones are uninteresting and undistinguishable from the mass of rubbish and flints of which they form so large a portion. But the practised eye recognizes them in a moment, and draws the proof of the fact from the comparison of examples downwards; from the most complete to the most imperfect; from the indisputable fossil-crab to the specimens which have but a fragment of the carapace or a single claw to mark them; from those, again, to such crab-shaped lumps of phosphate of lime, or even to mere pebbles, which retain nothing but the outline and configuration; yet, remarkably, the very shape of the body of the creature having a little indentation on one side, with a hollow or flattened place underneath, indicating the situation of the mouth and stomach of the original. And hence, whenever the roads and lanes of Sheppey are repaired with shingle, as they sometimes are, if we cannot say that they are paved with gold, we can declare that they are *strewn with crabs!* Such are the wonders of geology; though this is but one of a thousand proofs that every pebble, every flint, was once a living creature,—either zoophyte, mollusc, or crustacean; and that *every fragment*, however small and insignificant, is a page from the volume of the rocks, and has for us, if we would attend to it, its instructive lesson, its practical discourse. Let us open eye, ear, and understanding to the sermon of stones.

2.—" On Discoveries in the Lower London Tertiaries, at Dulwich and Peckham, during the Excavations for the Effra Branch of the Great South High Level Sewer." By Charles Rickman, Esq.

The autumn of 1859 witnessed the commencement of the main drainage south of the Thames, when my attention was directed to the open cuttings at Peckham. In the spring of 1860, the more difficult operation of tunnelling under the five fields at Dulwich, afforded practical lessons both to the engineer and the geologist. It was in the latter capacity I first became acquainted with the sections thus exposed, and having devoted every available leisure hour on these works—from October, 1859, to July, 1860—I venture to lay before the Geologists' Association a brief narrative of my discoveries during the progress of the excavations, consisting of an open cutting running from Peckham Rye to New Cross, and the tunnel at Dulwich. Now, there can be no doubt that the strata passed through constitutes a portion of the Lower London Tertiaries, distinguished by Mr. Prestwich as the "Woolwich and Reading Series," and I have it as that gentleman's opinion, that the six feet of clay on the top of the main shaft at Dulwich may belong to the London clay; and I must confess, that when I first visited the scene of operations at Peckham, I was so impressed with the analogy the different sands and clays bore to the familiar Woolwich series, both in their lithological and palæontological characteristics—as visible at Charlton and Blackheath—that I despaired of finding any additional fossil remains indicative of an extended fauna or flora; but a short acquaintance speedily led me to a very different conclusion. And here it is expedient I should explain that it was upon a huge spoil bank, near the Nunhead Cemetery, that I had so ample an opportunity of studying the organic remains, which was scarcely possible in the cuttings, on account of immense quantities of water, and the speed with which the sewer was constructed, and the opening filled up. Amongst this *debris* were masses of indurated clay, oftentimes of a highly crystalline character, making hydraulic cement, when burnt, equal to that manufactured from the nodules of septaria, so plentiful in the clays of the London basin and at Barton, presenting conchoidal fracture when broken contrary to the plane of stratification. It occurred about seventeen feet from the surface, having a uniform thickness of eight inches, and charged with myriads of casts of the well known fresh-water genus *Paludinæ;* it rested on an oyster-bed, made up of the remains of *Ostrea tenera* (Sowerby), *Ostrea pulchra* (Sowerby), *Ostrea Bellovacina* (Lamark), *Ostrea elephantopus* (Sowerby), a *Bysso-arca*—considered by Mr. Edwards to resemble *Arca-Cailliaudi* (Bellardi) from the nummulitic beds of Nice, *Cyrena cuneiformis* (Fér.), *Cyrena deperdita* (Sowerby), *Cyrena cordata* (Morris), *Melania inquinata* (Def.), *Melanopsis brevis* (Sow.), *Modiola Mitchelli* (Morris), *Calyptræa trochiformis* (Zam.), and *Corbula;* all (with the exception of *Arca-Calliaudi*) being well known and characteristic fossils of the Woolwich and Reading series.

I propose to distinguish the layer of indurated clay by the name of the

Paludina band; in addition to the smaller species, the well known *Paludina lenta* (Brand), I also met with three specimens resembling the *Paludina aspera* (Michaud), from the fresh-water limestones of Rilley la Montague, which may probably be the species recorded by M. De la Condamine as *Paludina Desnoyersi* (of Deshayes); that species, however, appears to be more globose than the specimen from Peckham. In Sowerby's "Mineral Conchology," plate 50, fig. 1, is figured a specimen from East Peckham, to which the name of *Paludina elongata* is affixed; it would be interesting to ascertain if either of the specimens on the table is referable to this species. Associated with the *paludinæ* were casts of a *unio,* resembling, if not identical, with *Unio Solandri,* and another undescribed species of *unio* of large size. These blocks separated easily in the centre, exposing surface-planes of comminuted shells, with here and there fish-bones, teeth, and scales, the latter resembling those of *Lepidotus minor.* Some blocks yielded very beautiful specimens of leaves, my most perfect specimen being now in the British Museum. I have failed, myself, to discover any insect remains of a definite character; but the researches of Mr. Evans clearly demonstrate their presence. A figure and description appears in the "Geologist Magazine," for January, 1861.

Again, when fractured contrary to the plane of stratification, the surfaces thus exposed were often darkened with distinct semi-ovate patches, which I have ventured to conclude may be the *opercula* of the *paludinæ.* Lastly, with regard to this *Paludina band* at Peckham, I must not omit to mention the discovery of specimens of a spiral shell, generally casts or much eroded, occurring at rare intervals amongst the *paludinæ,* which, from its apparent resemblance, was at first referred to the genus *Voluta,* and was supposed to resemble the well known Bognor fossil, *Voluta denudata* (Sow.).

These specimens were submitted to the attention of many friends and conchologists, and, despite the seeming anomaly of a marine shell occurring in juxta-position with an undoubted fluviatile genus requiring some slight amount of speculation to account for its presence, still it was gradually settling down as *Voluta denudata,* when an unexpected and fortuitous circumstance enabled me to clear up the mystery; for the spring of 1860 had now arrived, and with it the tunnelling operations were in full activity at Dulwich—the principal shaft had been sunk on an eminence in the five-fields, at the spot where the trial-borings had been made. These latter gave the several thicknesses of clay, sand, and gravel, approximating in accuracy to the working section, with the exception that in the trial-section, no mention is made of the shell-conglomerate. It became necessary to sink the shaft a depth of sixty-five feet, and then galleries were driven right and left; when, from the quantity of water, it was requisite to further sink what is technically called a sump, in order to drain the galleries. This sump collected the water, so that buckets descending whilst the skips filled with *debris* ascended, became filled with water, and in their turn reached the surface, and were emptied into troughs or shoots, the whole put in motion by a horse-gin; this was probably the simplest and most inexpensive machinery that could be used for such operations, of a purely temporary character. It was in the excavation of this sump that masses of the shell-conglomerate were first met with, imbedded in sandy-clay, the natural section presenting a fractured condition, commented on even by the workmen, who referred it to the action of a whirlpool. It was at this time, one or two lengths of the galleries having been excavated, and prior to the brickwork being put in, that I was invited to descend the shaft. I did so, and was much struck with the singular appearance of the several strata, consisting of intercalated bands of dark black clay, greenish sand, and hard shelly rock, all running off into thin wedges, gradually thickening east and west. To the eastward, the circular gallery was ten feet in diameter, passing through the tenacious black clay, some tons of which were lying near the mouth of the shaft on the occasion of my first visit. This clay was laminated, and in breaking up exposed very beautiful specimens of various kinds of leaves. These were not mere impressions, but the carbonized substance of the leaf still remained; and, as I have described elsewhere, "it was possible in many cases to lift the leaf from the clay;" and I perfectly remember on some days, when the wind was rough, choice specimens which I had exposed to dry were blown away. Oftentimes the leaves formed a thin blackish carpet over many square feet of clay. I had no difficulty in collecting some hundreds of these leaves. The choicest specimens may now be seen in the British Museum, and the Museum of Practical Geology. The most peculiar in form, occurring very rarely, was accurately figured in the "Illustrated London News," of March 24, 1860, by Mr. S. J. Mackie, F.G.S.

I will not assume to offer any opinion as to the botanical character of this flora. Leaves were plentiful which have a close analogy to the poplar, the willow, and the maple, now growing in the neighbourhood; but it would be difficult to find (except in the Tropical Department of the Crystal Palace, hard-by) any congener of those magnificent lanceolate leaves, with serrated edges, which here and there darkened the surface of the clay.

Lignite was very abundant, highly charged with iron pyrites. Very rarely I met with an obscure kind of seed-case, and what may either be the catkin of the willow, maple, or hazel, and one or two specimens of petro-phyloides.

In driving the galleries east and west it was soon discovered that the shell-conglomerate became regularly bedded, and ultimately attained a maximum thickness of four feet. It was sometimes intercalated with bands of stiff blue clay, presenting in section a series of wedges, and even some of the hardest masses contained cavities filled with soft clay. It had a dip east and west of the central shaft, which appears to mark the axis of elevation. Two more shafts were sunk to the eastward and one to the westward, presenting a general resemblance to that just described. The galleries, when united, formed the entire length (330 yards) of the tunnel, which was constructed of a circular seven feet barrel brick drain, set in concrete with Portland cement. The difficulty of the operations was much increased by the immense quantity of water occurring in the running sand.

Simultaneously with the main shaft, the first one to the eastward was sunk; and here, early in the spring of 1860, I succeeded in laying open a large block of stiff blue-black clay, having exposed on its surfaces many leaves and three pairs of shells, which at once struck me as differing in form from any of the *cyrenæ* which I had previously met with.

These were still covered with the epidermis; and it was also from amongst some broken specimens that Mr. Edwards was enabled to work out the hinge, and determine that it was a new species of *cyrena*, which I have named and described as *Cyrena Dulwichiensis*. Its specific characters are shell elongately oval, transverse, inequilateral, posteriorly slightly produced, and obscurely truncated; umbones prominent, tumid, curved; unule large, and of an oblong oval form. The anterior extremity presents on the surface numerous irregular and rather deep concentric furrows, which become shallower as they cross the middle, and almost obsolete over the posterior extremity. The shell is ornamented with irregular and longitudinal bands or rays of colour, usually eight or ten on each valve, but varying in number and breadth in different specimens. The shelly matter forming the coloured surface of these bands appears to have been particularly susceptible of disintegration, for most generally it was found to have been decomposed, leaving a perceptible furrow corresponding with the ray impressed on the surface. The hinge-lamina is much curved, and has three divergent cardinal teeth, of which the central one is slightly bifid, and two unequal compressed lamelli-form lateral teeth, strongly serrated. Length, 2 inches and 1·12th; height, 1 inch and 5-12ths.

At this very time the main shaft was yielding many tons a day of the shell-conglomerate, and I soon discovered that my new-found *cyrena* of the clay-beds was also tolerably plentiful in the conglomerate more strongly exhibiting the colour-bands. Here it was associated with *C. cordata, C. deperdita, C. cuneiformis, Melania inquinata, Cerithium funatum,* (Mantell), a large species of *unio,* and a smaller one, probably *Unio Solandri,* together with large masses of lignite pierced by a large and undetermined species of *Teredina;* also crocodile scutes, fish scales (resembling *Lepidotus minor),* and chelonian and mammalian bones. For several weeks I was unable to make out any univalve, with the exception of *Melania* and *Melanopsis,* and in the clay *Rissoa,* although I felt satisfied that I had observed some obscure fragments not referable to either of the foregoing; but one fortunate day a harder and more homogenous mass yielded a perfect specimen, followed the next day by the discovery of another. This pair of shells I submitted to the notice of the eminent palæontologist, Mr. F. E. Edwards, who has described and figured this new genus under the name of *Pitharella Rickmani.* For that gentleman's remarks on this shell, and his reasons for considering it referable to one of the three families *Auriculidæ, Achatinidæ,* or *Limneidæ,* I beg to refer you to the "Geologist," for June, No. 30, merely subjoining his description of the shell.

Pitharella (Generic Characters).—Shell sub-cylindrical; spire obtuse, more or less produced; aperture oval, oblong, rounded in front, narrowed behind; columella straight or very obliquely twisted, arched anteriorly; outer lip simple, inner lip thickened.

Pitharella Rickmani (Specific Characters).—Shell, oval-oblong, smooth; spire sub-conical, short, varying in height in different specimens; whorls, five or six depressed on the posterior margin, and obtusely angulated on the shoulders. The sutural edge is slightly thickened, forming a narrow, upright, ribbon-like band pressed against the preceding whorl, and feebly crenulated by the lines of growth; in well-preserved specimens, the margin immediately in front of the sutural band presents two or three obscure concentric furrows. The last whorl is somewhat attenuated towards the base; the aperture is entire, rounded in front, narrow behind, and very long, nearly equalling four-fifths of the entire length of the shell; the columella is obscurely and very obliquely twisted, and anteriorly is much curved. The outer lip is slightly arched, simple, and sharp on the edge; the inner lip is posteriorly thickened and narrow, anteriorly effuse, flattened and reflexed, forming an angular ridge on the columella and confluent with the outer lip. The dimensions of Mr. Edwards's largest specimen, if it were perfect, would be—axis, 2 inches and 2-12ths, nearly; diameter, 1 inch.

By comparison, it was soon ascertained that the casts occurring in the *paludina* band at Peckham were identical with the Dulwich *pitharella*. This induced me to revisit the Peckham excavations; and I then found tolerably perfect specimens, with the shelly matter still remaining, although in a very decomposed state. This identity is apparent by reference to the specimens on the table; and thus the mysterious obscurity in which the first specimens were shrouded is satisfactorily cleared up, and the *voluta* enigma solved.

Peckham.	Dulwich.
Fish bones, scales, and teeth.	Mammalian, Chelonian, Crocodilian, } Bones.
Leaves (rare).	Leaves.
Paludina lenta.	Fruit.
„ Desnoyersi.	Lignite.
Ostrea tenera.	Cyrena cuneiformis.
„ pulchra.	„ deperdita.
„ Bellovacina.	„ cordata.
„ elephantopus.	„ obovata.
„ edulina.	„ Dulwichiensis.
Arca Cailliaudi.	Paludina lenta.
Cyrena cuneiformis.	„ Desnoyersi.
„ deperdita.	Unio.
„ cordata.	Unio Solandri.
Melania inquinata.	Melania inquinata.
Corbula.	Melanopsis.
Calyptræa trochiformis.	Ostrea pulchra.
Pitharella Rickmani.	„ Bellovacina.
Melanopsis brevis.	Arca Cailliaudi.
Unio.	Modiola Mitchelli.
Modiola Mitchelli.	Pitharella Rickmani.
Fusus.	Teredina.
Buccinum.	Rissoa.
Rissoa.	Neritina.
Insect remains, discovered by Mr. Evans.	

The preceding lists indicate the number and species I have been able to make out at Dulwich and Peckham. A reference to them points to the fact that, in proceeding from the former to the latter place, we are as it were going seawards, as the shells are more purely marine at Peckham; or rather, that they there lie *in situ*, and in far greater numbers, whilst the estuarine shells are decidedly most plentiful at Dulwich, the conglomerate yielding shells of all stages of growth, and in countless myriads. Again, I am of opinion that the *paludina* band having comparatively the same mean level at Dulwich and Peckham, is due to the sudden irruption of some gigantic river charged with the spoils of a continent, as the eroded nature of the *paludinæ* and the *pitharellæ* at Peckham is a fact demonstrative of their having been transported a considerable distance. But then I am reminded by Mr. Prestwich, that the conditions of the London basin are ever variable and most perplexing; so that any attempt to define the configuration of land and water, and the limits of salt, lacustrine and fresh-water during the epoch of the lower London tertiaries is impossible with such a section as the one exhibited at Dulwich and Peckham.

The presence in the clay of myriads of many species and varieties of leaves, in some instances mingled together in undistinguishable black masses, and in others small leaves exquisitely preserved—the venations as strongly marked and the serrated edges as sharp as when they flourished on the parent stem—all speak to us of vernal and autumnal seasons affecting forests growing on the banks of some unknown and mighty river, subject to periodical changes in the level of its waters, which swept the land as it were of its organic remains and its alluvial deposits. That myriads of the *cyrenæ* were entombed whilst yet alive, I argue from the fact that in many cases the epidermis and hinge muscle still remained; and when first laid open, they shone in the sunlight with the irridiscent hues which of old they possessed in life. The small diamond-shaped and hard enamelled scales, together with palatal teeth, evidence the existence of fish closely allied to *Lepidotus minor;* nor are chelonian and crocodilian remains wanting, and what I have reason to suppose are mammalian bones. Some doubt has been expressed on this last head, and the specimens now exhibited are somewhat obscure; still I believe little doubt exists as to the true character of the bone I have deposited in the British Museum.

Lastly. Lignite was very plentiful at Dulwich, all more or less bored by a large and new species of *teredina*, some of the tubes being nearly half an inch in diameter, many having the closed valves of the mollusc at the extremity of the calcareous tube; it is worthy of remark, that the *paludinæ* and the casts of *pitharella* associated with them at Dulwich are much stained with oxide of iron, which has effectually removed all traces of the shell.

The Bysso-arca (*Arca Cailliaudi*) referred to as rather plentiful at Peckham, was very rare at Dulwich. I only saw one specimen sufficiently distinct to be identified.

Subjoined are the thicknesses of the several deposits passed through in sinking the shafts at Dulwich.

MAIN SHAFT.

	Ft.	in.
Virgin soil	0	9
Loamy clay (probably London clay)	12	0
Mottled clays	8	0
Mottled sands	4	6
Clay, with cyrenæ	6	0
Paludina band	0	9
Sandy clay	3	0
Oyster bed—sandy	1	8
Dark blue clay, with leaves	4	0
Green sand, with comminuted shells	7	0
Shell conglomerate fractured, maximum thickness in gallery	4	0
Sump. dark blue clay, with leaves, lignite, shells, and bone	14	0
Total	65	8

EAST SHAFT.

	Ft.	in.
Virgin soil	0	9
Loamy clay (probably London clay)	6	10
Red sand	5	6
Black clay, with leaves, lignite, &c.	2	2
Blue clay, ditto	1	10
Dark clay, ditto	1	6
Paludina band	0	8
Broken cyrenæ	1	0
Oyster bed	1	0
Blue clay, with leaves	1	8
Dark sand	2	4
Blue clay, with leaves	1	6
Dark sand	9	3
Hard shelly rock.. ..bottom	-	-
Total	36	0

West Shaft.

	Ft.	in.
Virgin soil	0	9
Loamy clay (probably London clay)	9	3
Dark clay	2	0
Paludina band	0	6
Light sandy clay, with leaves	1	10
Blue clay, with oysters	3	0
Dark sand	0	8
Yellow sand	2	0
Blue clay, with leaves	2	6
Dark loamy land	0	8
Blue clay, with thin layers of land	9	0
Running sand, with water	4	0
Light-coloured loamy clay	2	6
Hard shelly rock ..bottom	–	–
Total	38	8

In the gallery east of the main shaft the shell-conglomerate attained a maximum thickness of four feet; but in the extreme east and west shafts, the shelly rock forms the base on which the brickwork of the sewer rests.

The depth of the main shaft being so much in excess of the others denotes a considerable elevation at this point; but as the open cuttings now in progress are less than thirty feet deep, it is highly probable that for some time we must bid farewell to the highly interesting shell-conglomerate and its associated clays and sands.

Some specimens of insect wings, which had been discovered at Peckham, on the works of the Metropolitan Main Drainage, were exhibited by Mr. Evans.

A discussion followed the reading of the papers, in which Professor Tennant, Mr. Bingham, Mr. Rickman, Mr. Evans, and Mr. Bott took part.

⁂ The Committee propose, in April (if a sufficient number of subscribers can be obtained), to publish, *in full*, Mr. Cresy's paper upon the "Cretaceous Echinidæ," which was read before the Association during the last session. The memoir will occupy about thirty pages of letter-press, containing the generic characters of these fossils, and will be illustrated with four plates of lithographic diagrams of details, and six plates of *photographs* of the types of the different genera. The work will be accompanied with a brief description, by the Rev. Thos. Wiltshire, of all the British Cretaceous species hitherto published, in such a form as to assist the student in identifying specimens. The price to subscribers, before the end of March, will be five shillings. Members desirous of subscribing, are requested to forward their names to the Treasurer of the Association, W. Hislop, Esq., 108, St. John Street Road, Clerkenwell, E.C.

There will be an excursion on Whit-Monday, May 20, to some place of geological interest, of which timely notice will be given to the members.

Letters and communications to the Honorary Secretary, W. N. Lawson, Esq., may be directed either to the Rooms of the Association, 5, Cavendish Square, W.; or to 28, Chancery Lane, W.C.

The Annual Subscriptions for the year 1861 became due in January.

The following works have now, in accordance with the recommendation of the Annual Report, been added to the Library, and are ready for circulation amongst the members:—

Buckland's Bridgewater Treatise. New Edition.
Damon's Geology of Weymouth.
Juke's Manual of Geology.
Lyell's Principles of Geology. 9th Edition.
Mantell's Isle of Wight.
,, Medals of Creation.
,, Wonders of Geology. 7th Edition
Morris's Catalogue of British Fossils. 2nd Edition.
Page's Advanced Text Book of Geology. 2nd Edition.
,, Handbook of Geological Terms.
Phillip's Manual of Geology.

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

No. 7.] [Session 1861-62.

Ordinary Meeting, Monday, Feb. 4th, 1861.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—A. C. Hailes, Esq.; Dr. H. J. Sanderson.

The following donations were announced:—

Specimens of Fossil Ferns, from a Plant-bed cut into by the Severn Valley Branch of the West Midland Railway. By G. E. Roberts, Esq.

Mantell's "Fossils of the British Museum;" and

Woodward's "Recent and Fossil Shells." By W. Hislop, Esq.

The President announced that the Committee had purchased five pounds' worth of books, towards forming a Library for the Association.

The following papers were read:—

1.—"On Casts of the Calcareous Plates, or *Opercula* of *Ammonites*, in flint pebbles, from the gravel at Whetstone." By Nathaniel Thomas Wetherell, Esq., M.R.C.S., &c.

On looking over the last edition of Morris's Catalogue of British Fossils, published in 1854, I was surprised to find there was no notice of the *opercula* of *Ammonites* from the chalk formation. The only record under the head of *Trigonellites,** at p. 363, being an enumeration of six species from the oolite and lias.

In 1856, the Palæontographical Society published the third part of the late Mr. Daniel Sharpe's "Description of the Fossil Remains of Mollusca, found in the Chalk of England."

This part embraces the *Cephalopoda*, and a description is given at p. 53 of the genus *Aptychus*. A plate (numbered xxiv.) of all the known *Aptychi* of the chalk accompanies this description. From this plate, it appears that only six species are as yet known as occurring in the British chalk, namely:—

1. *Aptychus leptophyllus*. From the upper chalk of Brighton.

2. *Aptychus Portlockii*. From the upper chalk of Norwich, and in a flint pebble from the gravel near Croydon.†

3. *Aptychus Gollevillensis*. From the upper chalk of Norwich, and in flint pebbles from the gravel near Croydon.†

4. *Aptychus Icenicus*. From the upper chalk of Norwich.

5. *Aptychus rugosus*. From the upper chalk of Norwich.

6. *Aptychus peramplus*. From the upper chalk of Norwich.

It has been my good fortune, during the last two years, to discover casts of two species of *Aptychus* in the Whetstone gravel, in a good state of preservation, namely, *Aptychus Portlockii* and *A. rugosus*. I have a cast in flint of a portion of the outer whorl of an *ammonite* from the Whetstone gravel. It is, however, too imperfect for specific identification. On examining Mr. Sharpe's plate, it will be seen that the majority of the specimens are more or less broken, rendering it difficult, in some instances, to make out the exact configuration of the fossil. My friend, Mr. S. P. Woodward, of the British Museum, has made a valuable and interesting contribution to the September number of the "Geologist." At p. 328 of that work, he has described and figured a beautiful *ammonite*, ‡ from the inferior oolite of Dundry, near Bristol, with the *operculum in situ*. My reasons for bringing this subject before the Association are twofold:—in the first place, it is always useful and important to record fresh localities of fossils; and, in the next, it may have the effect of stimulating some of our younger geological friends to make a further search after these

* *Trigonellites*, Parkinson, 1811. *Aptychus*, Meyer. *Munsteria*, Desl.

† Discovered by Mr. Flower.

‡ *Ammonites subradiatus* of J. Sowerby.

interesting and curious remains; for more information is much wanted respecting them. The gravel-pits in the vicinity of London and elsewhere are well worthy attentive examination; and if the student does not succeed in finding the *opercula* of *ammonites*, he is very likely to meet with other objects of interest that will amply repay him for any loss of time or trouble.

2.—"On Oviform Bodies from the London Clay, Chalk, and Greensand Formations." By Nathaniel Thomas Wetherell, Esq., M.R.C.S., &c.

Twenty-one years have now elapsed since I first called the attention of Geologists to the occurrence of oviform bodies in the London clay.* I found them in the excavations for the London and Birmingham railway, between Euston-square and Kilburn. Of late years I have procured these corpuscules from other localities in the London clay, namely, Whetstone, Finchley, and Sheppey. Mr. Prestwich has also noticed similar minute remains in the Thanet sand.† There has been, up to the present time, a great difference of opinion among scientific men as to the probable origin of these bodies, and I purpose, in the present paper, to lay before the members of the Geologists' Association, some additional information, which may tend to elucidate the mystery which has hitherto hung over this interesting subject. I have placed on the table a series of specimens for examination, but I wish to direct more especial attention to two examples—one, from Victoria river, Australia,‡ the other, from the crag formation. The first specimen consists of a mass of wood, profusely pierced by a species of *Teredo*, with the long tubes more or less filled with oviform bodies. The second specimen also consists of a mass of fossil wood, containing many columns of these bodies, some of the columns run parallel to the grain of the wood, whilst others pass across it. I have also brought for your notice some flints, obtained from the chalk of Northfleet; and some other flints from the Whetstone gravel-pit. You will perceive, in these instances, that the bodies are irregularly grouped in patches, and also in columns, similar to the specimen from the crag before

* "A notice of some undescribed organic remains, which have recently been discovered in the London Clay formation." By N. T. Wetherell, Esq., F.G.S., M.R.C.S., &c. Charlesworth's "Magazine of Natural History," for October, 1839, p. 496.

† In Dixon's "Geology of Sussex," Table xiv., Fig. 34, a specimen is engraved from the Eocene formation of Bognor.

‡ This specimen was given to me by Mr. John Salter.

mentioned.* In one instance, the column appears to be covered with a thin membrane or sheath. In the "Annals of Natural History," Mr. J. G. Jeffreys gives a notice of an undescribed peculiarity in the living *Teredo marina.* Dr. Verloren pointed out to him that each of the tubes of the *Teredo* was protected by a thin, pellucid, and film-like membrane or sheath, which preserved the tubes from being clogged by the accumulation of flocculent pulp, &c., and preserved them from the attacks of animalcules.

Mr. S. V. Wood, in his valuable paper " On the Extraneous Fossils of the Red Crag," published in the Quarterly Journal of the Geological Society, for February, 1859, in reference to these bodies, states, " These small bodies have been considered by Mr. Prestwich (Geol. Journ., Vol. VIII., p. 247, pl. 16, fig. 11), as the eggs of mollusca, and by others as the spawn of crustacea; they have also been referred to a coprolitic origin; but that they are the ova of some animal seems the better opinion. They appear too regular in their arrangement to be the seeds of any vegetable."

I will here observe that the microscope does not reveal any structure.

The question may be considered, whether there is now sufficient data to decide that these oviform bodies are the rejectamenta of *Teredo,* or whether it must still remain open until further and more conclusive evidence is obtained.

3.—" On a plant-bed, cut into by the Severn Valley Branch of the West Midland Railway." By G. E. Roberts, Esq., Member of the Worcestershire and Malvern Naturalists' Field Club, &c.

No good account of the upper Coal-measures of Wyre Forest in Worcestershire has yet been published. Even Mr. Hull, in his recent book on the Coal-fields of England, devotes scarcely more than a page to a district six miles in length, by five in width, and is content to acknowledge that little is known about it. The Coal-field in question, however, in which a good five-foot-coal has been worked for years, and which contains several thinner beds, somewhat sulphurous in character, is of great local value to the many hop-growers who reside along its southern margin; for where sulphurous coal is not procurable to heat the kilns in which the hop is dried, brimstone has to be bought by the farmer. The beds are

* Mr. L. Barrett has presented me with two specimens from the greensand of Cambridge.

interesting also from another point of view, inasmuch as they abound with vegetable remains of great beauty, and in a fine state of preservation.

The lithological character of the bed which yields the richest treasures of fossil plants is that of a fine-grained yellowish-grey shale, very fissile, and somewhat inclined to crumble. It differs in character from any plant-shale of the *main*, or lower, coal-measures, with which every one is familiar by their exposures in the great coal-fields of England. The specimens exhibited* in illustration of these remarks, were obtained from the eastern bank of the Severn, about half a mile north of Bewdley, at a place where the railway is taken through the foot of a spur of the ridge which runs for the next four miles parallel to the river and the rail. Two beds of *fern-coal*, each about a foot in thickness, are here exposed, and upon these dark *brown* layers lie the lighter-coloured shales which contain the plants. These are chiefly ferns, belonging to the genera Pecopteris, Neuropteris, and Sphænopteris; of this last, a new species is abundant, with very small, but most elegant pinnules, in some cases showing fructification. This greatly resembles a delicate form of Hymenophyllum from New Zealand. Indeed, there is such a marked affinity in form between several forms of the Coal-forest age and the existing Filicinæ of New Zealand, that I wish particularly to call the attention to the fern fronds from that country, which I exhibit.

The new Dyctyopteris (*Woodwardites Robertsii*, Morris,) was first met with in these shales, which have also proved of value in determining the *stems* of some other genera. One curiously pitted rachis, which shows, in a very clear and beautiful manner, the attachment of the scales which clothed it in life, is very abundant in the bed, and forms, by the elegance of its areolæ, a pleasing object of study. The usual companions to these ferns are to be met with, namely:—leaves of Lepidodendra, stems with verticillate plumage of Asterophylites, and long sword-like fragments of Calamites.

A discussion followed the reading of the papers, in which the President, Professor Tennant, Mr. Lawson, Mr. Pickering, Mr. Cumming, Mr. Bott, Mr. C. Jones, Mr. Cresy, and other gentlemen took part.

* A considerable number of specimens from the plant-bed were placed before the members by Mr. Roberts.

Ordinary Meeting, Monday, March 4th, 1861.

Professor Tennant, F.G.S., Vice-President, in the Chair.

The following were elected members of the Association :—Mrs. Cannon, Dr. D. S. Price, — Leighton, Esq.

The following donations were announced :—

Fossils from the Tertiary Beds at Peckham and Dulwich. By C. Evans, Esq.

Casts of various fossils. By N. T. Wetherell, Esq.

Abstract of Proceedings of the Geological Society. By the Geological Society.

The "Geologist" Magazine. By the Editor.

Mineralogy and Crystallography, Orr's Circle of the Sciences. By Professor Tennant.

Memorials of the Geological Survey. Three Decades. By W. N. Lawson, Esq.

The following papers were read :—

1.—"Observations on the Geology and superficial accumulations of the north end of the Penine chain and adjacent depression." By J. Curry, Esq.

ABSTRACT.

The author first described the Penine as a chain of mountains, situated in the north of England, ranging north and south, and falling down from its highest point of elevation at Cross Fell, till it terminates on the north in the Tynedale depression, against Hexham, Hartley Burn, and Brampton; and he then stated, that his present observations were chiefly confined to the superficial accumulations on the northern slope of the chain, or rather more particularly to those a little to the north-east. He next made a few remarks on the diverging courses of the streams, in their upper parts, and on the nature of the strata which they cut through. The rivers Tyne and Wear were described as having their courses nearly at right angles to each other, and those of the Derwent, Devil Water, and the Allen, as diverging in the intermediate space, and that these streams, including the Tyne and Wear, for certain distances, pass through rocks abounding in lead, and afterwards enter the coal-formation. The Wear enters it in the vicinity

of Wolsingham, the Derwent at Allen's Ford, the Allen at Staward, and the Tyne a little below Earl's Bridge.

The author stated that the superficial accumulations were of a local character over a considerable area. On descending from the high elevations of the district, the drift-margin is entered at the following points, namely, a little above Waskerley, on the hill between the Wear and the Derwent, but inclining to the latter; about a mile south-west from Slealey, on the ridge between the Derwent and Devil Water; and again, near Allen Town, on the East Allen River. He had not had an opportunity of observing the drift-boundary on the Tyne, but had made an examination of the valley from Slaggy Ford to Alston, thence up Nent Water to Killhope Head, without finding a single specimen of primary rock. His observations, he considered, tended to show that the loose materials, overlying the strata for many square miles of surface in the upper parts of this region, are such as might be derived from the disintegration of local rocks, and that the detritus of distant rocks, which is spread over the lower tract, has not had its route over the ridge of the Penine chain north from Cross Fell, but that it has been brought from the west on lower ranges.

Previously to stating the result of his researches on the drift-boundary further west, observations were made respecting the geology on the north side of the great Tynedale-fault along the depression from Haydon Bridge westward. Remarks were also made relative to the rude columnarization of sandstone between Magna and Wall Town. The peculiar denudation of the basset-edge of basalt, in the neighbourhood of Greenhead, was noticed. Then the drift was described as manifesting itself in the form of small rounded hills in the valley near Rose Hill, and attaining an elevation, on the mountain-slope towards Rye Craig, of about two hundred and forty feet above the Rose Hill Station, thence ranging along by Talkin to Castle Carrock, where its margin is near the high end of the town. He stated that these researches, so far as they go, map out, to a certain extent, the area occupied by the drifted matter, as well as that which contains the waste of local rocks, which might fall down from a higher to a lower level.

The author remarked that the drifted materials were abundant at Castle Carrock and Rose Hill, and evidently diminished eastward, till they were only sparingly met with on turning to the south-east from Devil Water to the Derwent, particularly on the higher grounds to which they reach; and that, if the ratio of diminution continued in this direction, they would be still rarer in the vale of Wear. He stated that he had found what he considered to be Scotch granite in the valley of the Derwent, and endeavoured to explain its route through the Tynedale depression, under the consideration that the rocky ridge at Wall Town had been continuous westward through the valley at Greenhead, thus forming a road across the vale, whereby the granite from Scotland found a passage southward on to the skirt of the Penine chain, when the ancient ocean washed the summit of this ridge on each side.

In conclusion, he considered that the following inferences were deducible from the observations which he had made, namely, that the ocean had been more voluminous in former eras than at present; that its waters had washed the skirt of the north end of the Penine chain to the elevation of the marginal line pointed out; that the primary Cumbrian detritus had not been carried over the ridge of the chain into the upper drainage of the Tyne and Wear, but had been transported around the north end on varied shore-lines at a lower range; and that the predominating force of the waters had been to carry the spoils of denuded rocks along these shore lines from the west and north-west, to the south and south-east.

2.—"On the Opercula of recent Gasteropodous Mollusca." By J. Pickering, Esq., Vice-President.

At our last meeting, on Mr. Wetherell asking me, with reference to his specimens of Opercula of Ammonites, whether I had ever met with a bivalved operculum among the recent Mollusca, I answered in the negative, believing such a thing to be unknown, and I went on to state that all the recent opercula that had come under my notice were univalve, and were either shelly, or horny, or composed of both substances. But as this was said somewhat hastily, without full consideration, and as I was not prepared at the time to give an exact reply, I have since referred to the subject, and now place before the members the following description of the opercula of a number of species of Gasteropodous Mollusca, viz., those of—

Turbo marmoratus.
,, sarmaticus.
Natica duplicata.
,, caurina.
Nerita peloronta.
Delphinula laciniata.

Fulgar canaliculatum.
Murex ——
Fasciolaria ——
Buccinum undatum.
Ampullaria reflexa.
,, globosa.
Paludina vivipara.
Bithinia tentaculata.
Cyclostoma elegans.
,, siculum.
Cyclophorus canaliferus.
Helicina ciliata.

Operculated Marine Shells.

Turbo marmoratus has the operculum smooth and testaceous above, horny and pauci-spiral beneath, solid and ponderous. (The *opercula* of four other species of Turbo, in my possession, are all testaceous above, pauci-spiral and horny beneath. This appears to be the general character of the genus; but the upper surface differs very much in form in different species,—that of T. sarmaticus, for example, having a botryoidal, or tufaceous appearance).

Natica duplicata has the operculum thin and horny.

Natica caurina has the operculum testaceous and sub-spiral.

Nerita peloronta (or bleeding tooth nerite) has the operculum shelly; specimens of opercula of another species of Nerita, in my cabinet, show the articulated process by which it is fixed in its position, in the mouth of the shell.

Delphinula laciniata has the operculum horny and many-whirled.

Trochus has the operculum thin and horny and multi-spiral (the spiral form is very interesting).

Fulgar canaliculatum has the operculum claw-shaped, lamellar, and leathery-looking.

Murex. The *Opercula* of three species of Murex, the larger of which is supposed to be that of ***M. ducalis***, the next rugged one that of ***M. regius***, and the third is not identified; are all concentric, rugged, and gutta-percha-looking, with the nucleus subapical. (The sculpture of the muscular impression is well worth notice.)

Fasciolaria —— has the operculum claw-shaped, nearly smooth, and gutta-percha-looking. (The sculpture of the muscular impression of this shell is very decided.)

Buccinum undatum has the operculum lamellar, with the nucleus external; this is ill formed and leathery-looking, subject to strange variations, sometimes it is single, at other times double, and occasionally piled one layer upon another, as observed by Mr. J. Gwyn Jeffreys.

Operculated Fresh-water Shells.

Ampullaria reflexa has the operculum horny and concentric. (The shell referred to was received alive in the crevice of a log of Mahogany from Honduras, and is the one mentioned by Mr. Woodward in his "Treatise on Recent and Fossil Shells.")

Ampullaria globosa has the operculum shelly. (This shell has an internal ridge or fulcrum, on which the operculum rests, and is thereby not drawn into the aperture, as in all the previous examples. Here is also a monstrosity, or abnormal form of an operculum of the same species, where there are three opercula piled one on the other; this circumstance is very similar to that occurring with Buccinum undatum.)

Paludina vivipara has the operculum horny, concentric; it rests on the edge of the aperture.

Bithinia tentaculata has the operculum shelly, and resting on the edge of the aperture, similar to that of ampullaria globosa.

Operculated Land Shells.

Cyclostoma elegans has the operculum shelly, pauci-spiral. This is the only British land shell that has an operculum.

Cyclostoma siculum has the operculum shelly. (A number of this species were brought alive from Turkey, and after remaining several months shut up in a drawer came to my hands still alive and healthy.)

Cyclophorus canaliferus has the operculum horny, orbicular, thin, and many whorled.

Helicina ciliata: this has the operculum thin, shelly, lamellar. (Some of the species of this genus have a membranous operculum.)

From the foregoing remarks, derived from specimens in my possession, it will be seen that the opercula of the Marine, Freshwater, and Land Mollusca are composed of much the same materials, and vary in different genera, in nearly the same degree in each of the before-named three elementary divisions.

Formerly conchologists had nothing but the form of the shell to guide them in their generic groups, the animal and operculum being either unknown or disregarded; hence much of the confusion in the nomenclature.

But now that we are getting better acquainted with the forms of the animals, and their opercula, the latter is found to be of great generic value. I believe, indeed, that the study of Conchology has arrived at such a point, that the mere examination of an operculum, without even a view of its proper shell, will determine, with tolerable certainty, whether the shell to which it belonged was Marine, Land, or Freshwater.

3.—"On the Pitharella Rickmani." By J. Pickering, Esq., Vice-President.

On looking at the figures, and reading the description of, and remarks on this shell (of which at present I do not possess a specimen) by Mr. F. E. Edwards, in the "Geologist," Vol. III., p. 208, it appears to me that that gentleman has drawn his conclusions from the wrong source, and that the shell in question is much more nearly allied to the Pectinibranchiata than to the Pulmobranchiata, in which he has placed it, or to the Prosobranchiata, to which it was originally referred; that is to say, it is more closely allied to Ampullaria, Paludina, Melania, and Paludomus, among which, in my opinion, he is more likely to find a living analogue, than among any of the genera with which he and others have compared it, and which I think will appear evident by the specimens placed before you:—

Pulmobranchiata.	Pectinibranchiata.
Auricula auris-midæ.	Ampullaria ...... 3 sps.
Achatina perdix.	Paludina .... 3 "
" virginea.	Melania .... 1 "
Polyphemus glans. (Glandina truncata).	Paludomus ...... 2 "
Limnæus stagnalis.	
" pereger.	
Chilina, sp.?	

I wish it to be understood that I do not raise these objections for the purpose of cavilling at Mr. Edwards, for whom I entertain great respect, but purely to arrive at the truth.*

A discussion followed the reading of the papers in which Professor Tennant, the President, Mr. Mackie, Mr. Wetherell, and Mr. Cuming took part.

Ordinary Meeting, Monday, April 8*th,* 1861.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:— Rev. T. Cornthwaite, M.A.; T. Dexter, Esq.

The following donations were announced:—

The "Geologist" Magazine. By the Editor.

"Abstracts of the Proceedings of the Geological Society." By the Geological Society.

The following papers were read:—

1.—"On the Geology of the Isle of Portland." By W. Gray, Esq.

The Isle of Portland, bare, barren, and uninteresting as it may appear to a casual observer, is not, after all, without interest, and to none does it offer more attraction than to the Geologist. He looks upon it as a silent witness of mighty changes in the world's past history; he sees that its foundations, once deep below the action of the waves, entombed myriads of creatures that sported over its muddy surface; that next its rocks, rising through the influence of vast forces, emerged from the deep, becoming the home of mighty reptiles, and the nursery of a tangled forest; and that, finally, though in ancient days again subsiding, its soil received new deposits from rivers gently flowing over its land, and that at last it became in a subsequent period fitted for the habitation and use of man.

In position, it is situated in the county of Dorsetshire, nearly opposite

* Since writing the above I have had an opportunity, through the kindness of Mr. Jones, Mr. Bott, and other Members of the Association, of examining several specimens of the shell under consideration, together with the opercula found associated with it, one of which is unquestionably that of one of the species of Paludina found in the same deposit; the other, being oval and pointed, does not correspond with the aperture of the other species, and therefore it is highly probable to be the operculum of Pitharella Rickmani; should that prove to be the fact, on further investigation, "Pitharella" will become a member of the family "Paludinidæ."

Weymouth, and is connected with the main land by a remarkable bank of shingle, which extends for some miles, as far as Abbotsbury.

In configuration it is wedge-shaped, with the axis, or centre line of the wedge running north-east, and is composed of a series of strata, marine and freshwater, slightly inclined. The series of strata, though not everywhere exhibited together, yet when grouped as a whole afford a vertical section of about 525 feet; hard rocks of a light colour giving about 145 feet; dark brown sandy deposits about 45; and the Kimmeridge clay formation the remaining 335. The sides, which to the east and west present bold fronts to the sea, have been much affected by landslips.

At Black Nore Point, on the west side, a large mass of rock, composed of several layers *in situ*, has fallen down through a height of 40 feet, and continues compact. On the eastern side, south of Pennsylvania Castle, the beds of stone have been overturned in many places; to the north of the Castle, and between it and the prison the whole space is covered with masses of stone detached from the strata above. To the north of the prison, and along the north-east of the island, vegetation covers the irregular surface, and to the north and north-west, the atmospheric action of ages has softened down the rough surface, and formed the undulating slopes in that locality, which are crowned by the perpendicular cliff or escarpment of Portland Stone, below the crest of the hill upon which the barracks stand. At the north-west, the slope formed by the debris of the overturned rocks has taken its permanent angle of rest, and prevents any further slips above the villages of Fortune's Well and Chiseltown, both of which are built upon the subsidence of ancient landslips.

That the general aspect of the north and north-west slopes has not changed for hundreds of years, may be gathered from the fact, that remains of Roman and ancient British earthworks are still to be seen in various directions.

The slips have been promoted by the existence of fissures, which traverse the island from north-east to south-west, and extend from within a few feet of the surface down to the clay. It would seem, also, from the fact of the fissures being independent of any particular bed, that they were produced subsequent to the deposition of the most recent formation developed on the island. The direction of the fissures is so constant, that the quarrymen profess to *ascertain, very nearly, the hour of the day by the extent of shadow cast in the opening.*

In these cracks or fissures, which do not converge to any one point, and which for the most part are widest at the bottom, and gradually diminish in size as they approach the surface, have been discovered human remains, associated with the bones of the elephant, elk, wild boar, and other animals. The Portland fissures can neither be compared with the ossiferous caverns of Oreston, Kirkdale, Banwell, and other places, nor can they be properly called caves, for they are simply narrow openings, as was stated just now, not wide enough for any animal larger than an ordinary sized dog to enter. They also afford no assistance to the theory which supposes that the bones thus discovered are the remains of animals that were washed into those openings by the action of water; for the remains are not water-worn or otherwise injured, which should be the case if they had been washed in through those very narrow openings, or driven with any violence against the jagged and broken sides of the fissures. It seems, therefore, that the bones fell in from above, and this supposition is confirmed by the fact, that it is generally on projecting ledges that they are found.

Graves are frequently met with on various parts of the island, and from the discovery of vases, coins, and other articles in them, are acknowledged to be of Roman origin. These graves are generally sunk down into the calcareous slate of the Purbeck beds, and the body was deposited within a case, rudely formed of unhewn stones or slates—without the intervention of a coffin—the earth being filled in upon a covering of similar material.

It would appear that the human remains are only found in fissures *beneath the calcareous slate*, so that it is highly probable that the weight of the earth, in the above instances, caused the heretofore undisturbed layer of slate, between the graves and open fissures to give way, and launch its contents into the space below. Captain Manning, Her Majesty's Lieutenant of Portland, and resident magistrate, has in his cabinet at Portland Castle, a good collection of fissure bones, *skulls, and other human remains*, as well as the bones of the deer, boar, and other animals, found in fissures in the central quarries, and therefore *below* the calcareous slate. In a cabinet, in the office of the Commanding Royal Engineer, Vern Fort, there are also several specimens of bones, the latter having been found on the Vern Hill, where the calcareous slate is not developed. These bones *were not accompanied by human remains*. The fissure-bones of Portland are generally found in good preservation, usually separate, but often cemented together by carbonate of lime, the shells of land snails being rarely associated with them. In some of the fissures, passed through by the Vern Ditch excavation (described in the sequel), there were discovered numbers of shells, very delicate, yet well preserved, and similar to those described as common in the Loess of the Valley of the Rhine, viz., *Helix plebium*, *Helix nemoralis*, and *Cyclostoma elegans*. Numbers of them were detached, but they were principally cemented together with broken pieces of stone, and cherty fragments, into a concretionary mass, by a filtration of carbonate of lime crystallised, and encrusting each. The specimens obtained were 30 feet from the surface.

The several beds, as developed in this island, are shown in the annexed wood-cut, and may be enumerated as follow:—

Sand and gravel of the Raised Beach.

Belonging to the Purbeck series.

- Calcareous slate; 8 to 30 feet thick.
- Clay band.
- Bacon-tier; 1 to $1\frac{1}{2}$ ft.
- Clay band; 8 ft.
- Aish; 3 ft.
- Soft burr; 1 ft. to 14 in.
- Dirt-bed; 1 ft. to 16 in.
- Top-rising; 2 ft.
- Cap; 4 to 7 ft.
- Seam of black earth.
- Skull-cap; 20 in. to 3 ft.

Portland stone.

- Roach; 3 ft.
- Whit-bed; 9 feet. (The really best bed of stone.)
- Curf and waste, with chert-beds; 6 ft.
- Roach; $1\frac{1}{2}$ to 2 ft.
- Base-bed or lower tier, 5 ft. (Called also the "Best-bed.")
- Limestone and chert; 75 ft.

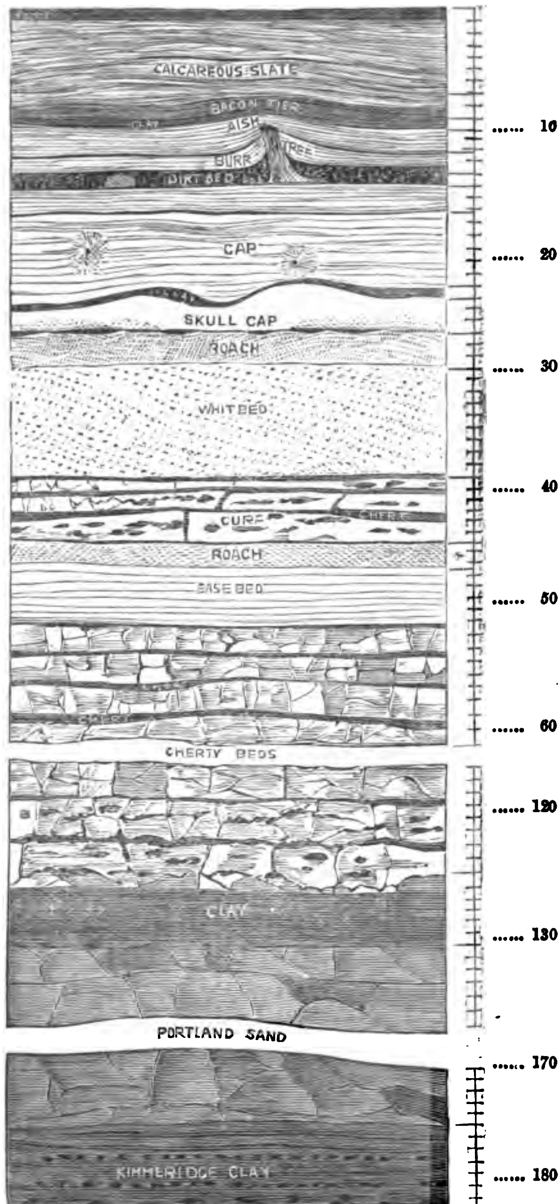
Blue clay; 8 to 10 feet.

Portland sand; 45 feet.

Kimmeridge clay, with septaria; 335 ft. seen.

These beds, beginning with the oldest and ascending upwards, may be thus described:—

The Kimmeridge clay forms the basis of the whole Portland series, yet it



SECTION OF THE STRATA IN THE ISLE OF PORTLAND.

is not well exposed in any part of the island. The slopes to the north, north-east, and north-west would afford the best points of examination had they not been overgrown by vegetation in that locality. It is laid bare by the waves along the coast, and large quantities of iron-pyrites are washed from it, and also septaria: sometimes, but rarely, small ammonites, and occasionally the bones of the pliosaurus, the specimens being charged with the pyrites, which give them a metallic appearance.

It would appear from certain indications on the north-east slopes, that the clay is made up of hard laminated beds, interstratified with bituminous shale, which, when exposed to atmospheric influence, soon becomes disintegrated, and is converted by moisture into a stiff plastic clay. It assumes this latter character along the margin of the sea, particularly under the west cliff, where it has been forced up by a recent landslip.

One of a number of graves dug up in the Roman earthworks, that existed on the site of the present fortification, was formed of the bituminous shale of the Kimmeridge clay.

The clay towards the top, and immediately under the Portland sand, is very hard in its native bed, and is sub-divided by layers of spheroidal nodules, some of which contain crystals in the centre. They are of different sizes, from three to ten inches in diameter, very solid and hard, with an external crust of concentric coats; they are disposed so regularly, that they appear in a section of the cliff as if artificially arranged in courses. The junction of the clay with the sand is ill-defined, as the upper portion of the clay and the bottom of the sand assimilate in their general character. The thickness of the clay, as developed in Portland, is about 335 feet.

The Portland sand, next above the Kimmeridge clay, and into which it gradually merges, is made up of layers of an olive-green-coloured limestone, divided horizontally by sandy beds, the mass being shattered and broken. So unshapely are the blocks of which the layers are composed, that if it could be conveniently quarried, it would be unsuitable for building-purposes. Some of the beds are soon destroyed by exposure to the weather; but others are comparatively unaffected, and the exposed surface becomes covered with lichens, as may be seen on several of the overturned blocks on the north-west slope. The thickness of the Portland sand is about 45 feet.

Occupying an intermediate space between the Portland stone proper and the Kimmeridge clay, the Portland sand may be considered the transition series, but notwithstanding this graduated development of the solid Portland beds, it is not easy to comprehend how it comes to pass that they overlie a formation very little altered at present from what we should suppose the Portland stone beds were when first deposited. What consolidated the Portland beds? If pressure produced the effect, why should the clay below remain unchanged? In the Portland sand, like in the overlying strata, are found fossil casts of ammonites, trigoniæ, &c.; it might have happened that the shells decomposed as they lay in the original silt or sand, and that the carbonate of lime thus supplied was taken up by water, and distributed throughout the strata, and, again crystallizing, consolidated the mass interposed between the beds of clay, the latter, by its impervious character, preventing the filtration of the water.

Above the Portland sand, and between it and the Portland stone, there is a stratum of blue clay, about eight or ten feet thick. This receives the surface drainage, after percolating through the several layers of the Portland stone, and therefore it becomes the source from which the fresh-water-supply for the island is procured. As the dip of the strata is rather to the south-west, in that direction—wherever this clay crops out, or shows itself in section on the cliffs—there will be seen small streams issuing between the clay and the overlying beds. In the caves and fissures the surface-water may be found making its way downwards to the clay, and it is this that in its passage takes up lime in the upper beds, and deposits it again in the form of stalagmites and stalactites in the fissures and the open spaces below. A beautiful example of a stalactite cavern was met with last year in a quarry belonging to Messrs. Freeman, near the Church: this cave was about thirty feet long and twelve feet wide, and hundreds of stalactitic columns, of various forms and proportions, connected the ceiling with the floor. The ceiling was rather flat, but the floor was very irregular and broken, a circumstance which added much to the beauty of the whole, for every portion of it was incrusted with a transparent coating of carbonate of lime, and the course of every dropping was well defined by this beautiful deposit. Some of the columns were grouped in clusters like organ-pipes; others, fragile and delicate, not stouter than a goose-quill, hung by hundreds from the ceiling to the floor.

The surface-water, when it reaches the clay, flows along its surface until it finds an outfall in the cliffs as it crops out on the slopes, or

"Royals," as they are locally termed, below the Vern Hill. The inhabitants in that locality are well supplied with water, a fact which gives the name of Fortune's Well to the principal village.

So bountiful is the supply, that some persons on the island believe that it does not depend upon the rainfall, but that the main spring is *beyond* the island, and that the water rises up through some open gullies; or that it is derived from the surrounding sea, and, rising by capillary attraction, is purified and freshened by the process. Such ideas are entertained under the conviction that there is more water used by the inhabitants than falls from the clouds.

Now, it so happens, that the physical conformation of the district above noticed, is most favourable for retaining the rainfall, and directing it to one point, *i.e.* Fortune's Well. Taking the surface thus drained to embrace the space bounded on the west by a line drawn from the Church below the Hill, to the Rectory, on the north and south, by two parallel lines drawn respectively from the above points to the eastern cliff, which latter forms the eastern boundary, we have an area of at least 120 acres; then, taking the rain-fall at two feet for the year (the actual rain-fall for the last five years being—

For 1856	- - -	28·690 in.
1857	- - -	23·480
1858	- - -	19·955
1859	- - -	25·560
1860	- - -	30·770
Total	- - -	128·455

or an average of 25·69 inches), if we take 24 inches as the depth of rain-fall, and 120 acres as the area drained, we obtain about 65,251,800 gallons per annum, or 178,700 per day. Then, considering the population of the villages supplied from this source at 2,000 (which is nearly correct), and allowing 20 gallons per day for each individual, there will be left for evaporation, absorption, and overflow 138,700 gallons per day, or a constant flow of 5,780 per hour throughout the year, which is certainly not less than the actual waste.

The other villages on the island are very badly supplied with water, for being situated *above* the hill, well-shafts must be sunk through the entire

Portland series of beds, an operation found so expensive, that there are only a few wells sunk for the accommodation of several villages.

Leaving this stratum of clay (the blue clay), we next, in an ascending order, meet with a series of solid beds of stone interstratified by layers of chert, making up a total thickness of 75 feet; the thickness of the several layers varies considerably, yet the general characteristics of each are very similar; they are all fossiliferous, they are all broken and shattered, and there is not a bed in the series of any marketable value.

It is through this series that the Vern Ditch (in connection with Portland defences) is cut, where a most favourable opportunity is afforded for its examination and study. This cutting, when finished, will, in the aggregate, make up a length of 1,100 yards, by in width 100 feet, and in depth from 30 to 75 feet. From this, the enormous quantity of 1,073,000 tons must be removed. The excavated material is used in constructing the Breakwater now in progress, under the Admiralty, in Portland Roads.

The first thing that strikes the visitor in this excavation is the extraordinary regularity of the strata; a narrow bed of stone between layers of chert can be traced for a long distance, and many of the beds as developed here can be recognized again on the cliffs on the eastern and western sides of the island; some beds are subdivided and again united within a short distance, one bed in particular, showing a thickness of 14 feet at the eastern entrance to the ditch, is subdivided within a short distance on that face into several beds.

The general thickness of the beds of stone is from two to five feet, and the cherty beds vary from six inches to three feet. Sometimes the chert runs from one layer into another, and very often the rents in the bed of stone between two layers of chert are filled up with chert also, so that it looks on some sections like vertical, or *almost* vertical, markings made with a tar-brush. The horizontal beds of chert, where a fresh section is opened, appear almost black, and contrast strongly with the light colour of the intermediate beds of stone. This difference of colour is soon mellowed down by the growth of lichens and other vegetation. Some of the cherty layers are made up of shells, and in the upper beds of this series cherty nodules are not uncommon, which, when broken, show a shell in the centre. These nodules vary from the size of an egg to the size of a heavy cannon-shot. In the lowest beds the chert is in irregular patches, as if collected round a branched nucleus, and a section shows a number of parallel lines from the centre to the surface of the mass, disposed in concentric rings.

The beds, so remarkably regular, and almost horizontal in the cross section, suddenly dip at a considerable angle (30 degrees) on the east and west faces. This seems to have been caused by slips parting in the direction of fissures, and becoming thus tilted over in the direction of the slopes already described. The ditch in one direction, on the west face, is cut through a slip of this kind; and on the east face the tilted nature of the strata causes a difficulty in forming the contemplated perpendicular escarpment. This phenomenon, manifested also in other portions of the island, was evidently caused by the wearing away of the underlying clay and sand, the destructive effect of which was promoted by the existence of the fissures.

These beds, though highly fossiliferous, do not easily afford perfect specimens in the quarries, the shells being incorporated with the stone; but where the stone is exposed for many years to atmospheric action (as on the faces of the cliffs), shells, being less acted upon by the weather than is the mass in which they are enclosed, then stand out in bold relief. Crystallized casts of shells abound in some of the lower beds. The principal fossils of the series are as follow:—

Ammonites giganteus.
,, biplex.
Cardium dissimile.
Trigonia gibbosa.
,, incurva.
Ostrea expansa.
Pleurotomaria rugata.
Vertebræ and other bones of the Plesiosaurus (?)
Isastræa oblonga.
Serpulæ.

The fossils are not confined to the calcareous beds, for they are also plentifully distributed through the cherty layers; even the great ammonites are sometimes enclosed in the chert.

The ammonites are found in every bed, and in some, in great numbers. In one of the Admiralty quarries, on the east side, between the Prison and the Vern Fort, a bed of this series is stripped for a considerable space, and the ammonites (the "congers" of the quarrymen,) are scattered about in all directions. They lie flat on the bed, half imbedded in the stone, and half above its surface. In the lowest beds of this series, numbers of vertebræ have been found, sometimes as many as 12 in natural order; but, whenever a discovery of this kind is made, the men of the discoverer's gang all scramble for "speses" of the bone, so that what an *individual* may secure is of very little value. Saurian teeth, and the dorsal fin of a shark, have been also found in these beds.

Upon a close examination of the beds as developed in the Vern Ditch, the observer will discover tracings of what appear to be ancient river-courses. An example of this may be seen at the bottom of the Ditch, near its eastern end. A space of about three feet by two has been carved out of the stone for a considerable length, and is now filled in with sand and clay. This is first seen on the face of the eastern cliff. It appears again on the counterscarp of the ditch, and continues at the other side, running under the Fort. The clay and sand now filling up the courses are deposited in alternate layers, and represent, in miniature, the original state of the whole Portland series; it is, in fact, a register of the differences in quantity and velocity of the water that once flowed through those courses, changes wrought by the variations of the weather in the locality from whence the current had its rise. The pebbles contained in the deposit are angular, yet worn by attrition, and they are all covered by a black substance which, when rubbed between the hand, gives them a polish, as if with black lead.

In excavating for the foundation of the casemates on the south-west flank, a large quantity of clay was met with, through which was interspersed fragments of bone, pieces of fossil wood from the "Dirt-bed," flints, and broken pieces of stone, all blackened on the outside, similar to the pebbles of the water-courses described above, and they appeared besides to have been subjected to the action of fire. Some of the pieces of stone had an incrustation of an enamel-like substance on the outside, about the thickness of cardboard, but all the inside was soft as chalk; sometimes the centre retained the colour and hardness of flint. The pieces of tree were also blackened on the outside, and when broken, they presented a calcined appearance. But the most singular circumstance connected with this local deposit, was the quantity of broken stone that it contained, belonging to the fresh-water strata of the Middle Purbeck series, a bed not developed in any part of the island. The fragments distributed through the above clay deposit contained species of *cypris*, *paludina*, *cyrena*, *planorbis*, and *cyclas*, with seeds of *chara*. This will seem the more remarkable when we remember that the clay in which the above specimens are found is deposited in the cherty beds above described, which are the *lowest* of the Portland series; but in the locality now under consideration they crop out at the surface.

Leaving the cherty beds, we next come upon the "lower tier" of the Portland stone proper, or "Base-bed," commonly called the "Best-bed." It is the oldest bed reached by the quarrying operations of the island for trade purposes.

On the Vern Hill—which is a comparatively level space of about 50 acres, at the northern end of the island, bounded by the slopes described in the beginning of this paper—the Base-bed has been quarried to a limited extent; but, as might be expected from its geological position, the quantity was scanty and of inferior quality; for in Portland the beds, whether they merely crop out by running with a quicker dip than the fall of the surface, or run parallel with the surface, in either case, are very much broken and shattered for about eight or twelve feet from the surface. The Base-bed, in this shattered condition, extends over the greater part of the Vern Hill. It runs out to the south as it approaches the Ditch, and from abou 200 feet at the other side of the Ditch, where it again crops out, it continues all over the island.

The local term "Best-bed," as applied to the stratum now under consideration, has caused no little confusion and disappointment; for, though it possesses the finest texture and the most uniform colour of any bed on the island, it is not really the best for many of the purposes to which it is at present applied; it is liable to rapid decay when exposed to the weather; but, being soft, it is easily and economically sawn into any size, and therefore meets with demand in the market. There can be no objection to its use for *inside* work, where it answers admirably, and the wonder is, that it is not oftener so employed; but, for *outside work* it is ruinous. The misapplication of the term "Best-bed," and the injudicious employment of it for works exposed to atmospheric influences, had created a considerable prejudice against it, and many thousand tons that should have been quarried in Portland are left behind, and covered up in the *débris* quarried from the other beds. The term "Best-bed" may be a corruption of the term Base-bed, the latter being most correct when applied to what is commonly called the Best-bed, for it is the *base*, or lowest bed quarried in the Isle of Portland. It is very uniform in its texture and colour, free from fossils, and may be had in any reasonable sized blocks, not more than five feet in one direction, this being the average thickness of the bed.

Overlying the Base-bed, and closely associated with it, there is a bed of " roach," from eighteen inches to two feet thick; this bed abounds in fossils, casts of *Trigonia incurva, Trigonia gibbosa*, &c., &c.; and, the calcareous matter of which they are composed being of a firm texture, the casts are generally clearer and sharper than the same kind of fossils in the upper and coarser beds.

Between the roach of the base-bed, and the Whit-bed, or really *Best* bed, there intervenes a bed, or beds, called by the quarrymen " curf," and " waste;" this is divided from the underlying, as well as from the overlying beds, by layers of chert, and is often subdivided by similar layers; the quality of the stone, too, varies considerably, and is *never* fit for *particular* work. In some of the quarries, as on the eastern side, the curf is very much like the Base-bed, and contains very little flint or chert; towards the centre of the island it is more like the roach of the Base-bed, and contains similar fossils, but in the western quarries the curf is worthless, and is all thrown aside with the waste; its general thickness is about six feet, it is sometimes much more, and often considerably less; indeed, it is absent in one or two places, or only represented by a layer of oyster shells. The curf contains similar fossils to the roach of the Base-bed, but in less quantity.

Next above the curf is the Whit-bed, or the true Best-bed of Portland stone. The local term Whit-bed is a misnomer, and like the term Best-bed, as applied to the lowest bed, leads to confusion; for Whit-bed, in contradistinction to Best-bed, implies that the former is whiter and second in quality to the latter, whereas, in reality, the Whit-bed is the *darkest* and *best*, and (what is called) the Best-bed is the *lightest* and *worst*.

Architects should carefully note those distinctions. The texture of the Base-bed differs from that of the Whit-bed, in that the former is comparatively free from fossils, whereas the latter contains a great quantity of comminuted shells, the fragments being just small enough to impart a light brown tint to the stone, without giving it a speckled appearance.

The durability of this stone, as compared with the Base-bed, may be occasioned by the quantity of crystallized carbonate of lime by which it is impregnated, derived from the contained shells. The centre of the Whit-bed proves the best for exposure to weather, inasmuch as the top, and more particularly the bottom, of the bed is much softer. A knowledge of this fact is necessary to the proper disposal of this stone in architectural works, and to counteract the injurious effect of the workmen's practice in dressing the top or bottom of the bed for the fine or exposed surface. The Whit-bed is generally about nine feet high, and is necessarily split up into smaller blocks before it leaves the quarry. When a block, the full height of the bed, is parted in the centre, two stones are produced, each of which has a hard and soft face, the hardest being that part nearest the parting joint, and the softer, the parts next the top and bottom of the bed respectively.

When a mason is given one of these stones to work, he selects the softest part for the face, taking the least amount of labour to produce the more particular surface required; the result must therefore be to the disadvantage of the stone. Whereas, had the centre portion of the original block been selected for the face-work, the result would be more durability, as well as uniformity of colour. The foregoing observations apply more particularly when the stone is laid *square* with the direction of its bed, and not "*on* its natural or quarry bed," as is generally specified, and, indeed, most necessarily so, when the stone is of a laminated or fissile structure; but with Portland stone, for the reasons stated, it is questionable whether any advantage would be derived from insisting on laying the blocks on the quarry-bed; it would require constant, untiring supervision to secure the fulfilment of such a condition, and very few, except the practical workman, can detect in some blocks of Portland stone which way the bed runs, unless by the difference in quality between the centre of the layer and its top and bottom; and when this difference is apparent, it would be, indeed, unwise to enforce the above rule, viz., "that every stone should be laid on its natural or quarry-bed."

The quality of the Whit-bed—*like all the other beds in Portland*—varies considerably; for example, in one part of the Admiralty quarries it is exceedingly rough and frothy, containing numerous shells and white spots of a calcareous substance; the latter crystallized in concentric rings; whereas, *in the same quarry*, nay, *even at the other side of a joint* or parting, the stone assumes its usual fine and uniform texture. It would be useless attempting to account for this phenomenon, but such is the fact.

Generally speaking, the beds produce the best quality of stone northwards. At the north-west, both Whit-bed, and Base-bed, are of excellent quality; farther south, the Whit-bed reaches its highest degree of perfection, but the Base-bed fails in quality; at the south-west both are inferior. On the east side of the island the Base-bed is very good, and the Whit-bed is coarse and shelly; both beds are again deteriorated in quality southwards. The same difference in quality may be noticed in the curf and roach. The former may sometimes be found *almost* equal to the latter, but, as a rule, the distinction between curf and roach should always be observed, and the former *never* put where roach is intended, particularly in exposed situations, as sea-walls, or docks. What has been said relative to the curf equally applies to the roach of the Base-bed, already noticed.

Overlying and closely associated with the Whit-bed is the celebrated Roach a local term applied to a layer of about three feet thick; made up almost entirely by casts of various shells, such as a *Cerithium Portlandicum, Trigonia incurva, Trigonia gibbosa, Neritoma sinuosa, Pleurotomaria rugata, Lucina Portlandica, &c.* This is the only bed in which "the screw," or *Cerithium Portlandicum,* is found, and here it is in the greatest abundance; not a fragment of Roach can be picked up without some portion of this shell; so thickly are those casts crowded together, that they frequently run one into the other; it is not uncommon to get a *Cerithium* in the cast of a *Trigonia,* or the cast of a small *Cerithium* in another. All the fossils of the roach, except the *Ostrea expansa,* are merely casts, not a vestige of the original shell is left, nor is the space it once occupied filled up by any calcareous matter; a clear space is left round the cast; it is this circumstance that gives the stone its spongy or aerated appearance

For durability the Roach cannot be surpassed, yet, notwithstanding this latter quality, it has not heretofore met with much favour in the market; hence thousands of tons quarried and squared up, have for many years been left lying about in all directions in the quarry-heaps, and hundreds of tons more have been covered up in the quarry *débris* or "tipped" over the western cliffs; latterly, however, it has received more attention, and it is now beginning to be extensively employed on large works of all kinds where its roughness is not an objection; for docks, sea-walls, heavy abutments, or bridges, it answers admirably.

In selecting even this bed for building-purposes, care must be taken that no portion of the Curf-bed, or even the Roach of the Base-bed is substituted; for, unlike the Roach proper, neither of the latter will stand the weather, nor are they by any means as strong as the best Roach. Though very much alike in appearance, the good Roach is easily distinguished from the others by its darker colour; it is more siliceous; and the cast of the *Cerithium Portlandicum* is *peculiar* to it.

The Roach-bed is, on an average, about three feet thick, and blocks of almost any lateral dimensions can be procured from the quarries; blocks are sometimes raised containing so many as twenty tons. The bed is made up of three layers; the lowest is rather compact and close-grained, resembling the underlying Whit-bed. In the west quarries this lowest division of the Roach contains the peculiar white, cylindrical crystallizations noticed in the rough Whit-bed of the Admiralty quarries. The centre division is that which gives the Roach its peculiarity, being made up (as described above) of numberless casts of shells; the upper and smallest division of the Roach is rather laminated, and resembles in a faint degree the calcareous state of the overlying beds; these three divisions are not easily divided, they are all closely combined in one mass. It is remarkable that the Roach-stone will not cleave readily in the direction of a plane parallel with the bed, or line of deposition. The quarrymen invariably cleave it in a direction square with the bed, and the fracture thus produced is uniform and regular, whereas, if the stone were split *with* the bed, the fracture would be irregular and wasteful.

The Roach is the most recent formation of the Portland series; immediately above it comes the first bed of the Purbeck; but between those beds, and more particularly attached to the Roach, there are irregular patches of flints, full of shells; in the upper surface of the flints the shells are especially well preserved. The variety of shells here discovered is very great, from the large oyster and pecten to the smallest cyrena, but it is difficult to detach perfect specimens, owing to the refractory character of the flint; polished specimens, and pebbles from the beach composed of it, give very good sections of the shells which it contains.

The next bed above the Roach is the "Skull-cap," so called from its position with regard to the Roach: though thus closely associated, they are essentially different, the Roach being of marine origin and belonging to the Portland series, and the cap of freshwater origin and belonging to the Purbeck series. The skull-cap, which is one division of the overlying cap, is, like the latter, most irregular, and as to shape and texture, has no constant thickness; for example, the skull-cap, in one part of a quarry may be only twenty inches, and within a short space it may swell out to a thickness of three feet or more; the overlying cap, taken together with the skull-cap makes up a deposit having a total thickness of from nine to twelve feet; the irregularities of the upper surface of the skull-cap corresponding with the uneven bed of the cap, the ridges of the one fitting into the hollows of the other: but they are divided by a layer of black earth, resembling the Dirt-bed, and which occasionally, like the latter, contains cycadeæ. In the cap there are circular perforations of about four inches in diameter; they resemble very much the holes drilled for blasting, were it not that the stone for about ten inches all round the hole, differs materially in its texture from the main block, being vesicular and porous, and seems as if some crystallization had taken place around some substance once occupying the now vacant space; this appearance is the more remarkable in the cap, otherwise compact and close-grained, not even presenting the oolitic structure. The upper portion of the cap is more laminated than the lower, and about two feet of it is easily separated from the top; this thickness is called the "top-rising."

We now come upon the most peculiar of all the beds in the island of Portland, that of the "Great Dirt-bed." This is a layer of black mould from twelve to sixteen inches thick, containing silicified stumps of trees and remains of cycadeæ, with rounded stones about the size of an egg. If it is difficult to account for the *solidity* of the Portland beds superimposed upon *clay*, it is a matter of no less surprise and difficulty that the fossil remains of plants should be converted into a hard siliceous stone, while the soil upon which they grew preserves its character unaltered. Of the abundance of vegetable life once flourishing upon what is now the Isle of Portland, we may have ocular demonstration wherever the Dirt-bed is exposed, either on the flat surface, or in section on the cliffs or quarry-face; there we see the prostrate giants of the forest, as if felled by the swoop of some terrible tornado.

The stumps, for from two to four feet high, continue erect as they grew, but they lean in the direction of the fallen trunk; their average size is about twelve inches in diameter, some few are over two feet in diameter some of the prostrate trunks are from twenty to thirty feet long, but never in one continuous length, being always broken into short pieces about twenty inches long; a length of three or four feet *in one piece* is rarely obtained, and, this being the case, it is difficult to identify the branches, the dividing stems being broken off short at the fork, nor can the roots be distinguished from the tree itself, as they extend in the same horizontal direction. If the mould be carefully removed from about the upright trunks, the roots will be seen running in all directions, but broken into short pieces similar to the main trunk; there is no leading root running down far into the soil, for roots and branches are contained in this twelve-inch layer of black earth, and neither penetrates the underlying bed, so that if the original tree had no better hold in the soil than what the lateral roots could give, it is no wonder that they were blown or washed down easily; but this was not the case, for the portions still retaining their upright position show that the force required to break them short off, within a foot or two of the ground (or roots), must have been very great indeed, while the shattered fracture of the broken tree proves that the timber did not yield without considerable resistance.

In examining the Dirt-bed there it no difficulty in identifying the fossil wood; it looks exactly like ordinary weather-worn timber, stripped of the bark, particularly those coarse-grained sorts, as elm and oak. The bark is not preserved in a petrified state, but is sometimes found like lignite, attached to the outer surface of the siliceous fossil, not even compact enough for removal.

The cycadeæ found are of two species—*Cycadites megalophyllus* and *Cycadites microphyllus*. The trunks are found tolerably perfect, and vary in size; sometimes they are twelve or fourteen inches high, and the same in diameter, but more generally they are about ten inches in diameter, and from four to six inches thick; in the latter case they are called "Birds' nests" by the quarrymen. Besides the fossil wood and cycadeæ there are no other organic remains found in the Dirt-bed.

Immediately above it there is a bed about twelve or fourteen inches thick, called the "soft burr." It is used in the island for building dwelling-houses, which its soft porous nature causes to be exceedingly damp. The upright stumps of trees from the Dirt-bed penetrate the burr, so that when the latter is cleared for any considerable space, the trees appear above its surface, as from the surface of the natural soil, and the burr is formed into a ring or conical heap round the tree, resembling the mound sometimes formed for protection at the base of tender trees in parks and plantations.* Associated with the burr is the "aish," which is more fissile than the burr, and about three feet thick. Above the aish there is a band of clay, about eight feet thick; then the "bacon-tier," a foot or eighteen inches thick; above this, another clay band; and then comes the calcareous slate, the uppermost layer of the island. Up to this deposit all the beds or seams from the Dirt-bed are very much contorted, owing in a great measure to the erect trunks of the fossil forests. In some places, too, the calcareous slate is disturbed, and very often yields in the direction of fissures below it, showing, on section, as if the slate was forced into those openings by rushing waters. Towards the north of the island the calcareous slate is about eight or ten feet thick, and is very much broken up; but, at the southern part, it is increased to twenty or thirty feet, made up of several solid though fissile beds, interstratified by clay bands of from an inch to twelve inches thick.

There are no fossils found in the beds between the Dirt-bed and the calcareous slate; nor will the quarrymen admit that any can be had from the slate; nevertheless, there are numerous scales and minute bones of fishes, as well as palatal teeth, &c.

From one of the western quarries I have secured two very perfect specimens of fish—one *Lepidotus minor*, the other, of the genus *Microdon* (?). Captain Manning, of Portland Castle, has some good specimens of fish from the calcareous slate in Portland.

Having passed through the several beds, as they are developed in Portland, it is only necessary to notice the ancient raised sea-beach of the "Bill," to complete our survey of the geology of the isle.

To the south of the island, on the west side, and close to the Bill (or the most southern point of the island), there is an extensive deposit of gravel and sand resting on the cap, being the accumulation of an ancient sea-beach. It is now raised about twenty-five feet above the water, and is deposited in alternate layers of coarse and fine gravel and sand. Here and there rents or fissures occur, which are filled up with

* Some fine large specimens of the "burr" of the silicified trees, and of the "roach," are preserved in the gardens of the Royal Botanic Society, Regent's Park.—Edit.

clay, a circumstance worthy of observation ; for, if it can be discovered that those rents are but continuations of the fissures in the underlying stone, it will go a great way to prove that the latter were produced subsequent to the deposit and elevation of the beach. Some of the gravel has been consolidated into a concretionary mass, by the infiltration of a calcareous matter, so as to form a conglomerate, or pudding-stone.

It is from this that the sand used for building-purposes on the island is obtained, thousands of tons being used on the extensive works in progress on the Vern Hill. There are no remains of shells, or other organic body, found in those sand and gravel-pits, but on the east side, and north of both lighthouses, to the edge of the cliff, there is another deposit of a finer description, which is full of shells and roots of plants; one layer, of about seven inches thick, is composed entirely of shells in a perfect condition, and where they are exposed in section they are conglomerated together like the pebbles of the pudding-stone. Thousands of those shells can be gathered in a few minutes. The deposit is about forty feet above the level of the sea.

From the above remarks it will be seen that a visit to the Isle of Portland will well repay the inquiring geologist, who will find a full week's enjoyment rambling over its cliffs, numerous quarries, and rocky seaboard, and who cannot fail securing, by the exercise of his eyes, hands, and hammer, very many specimens. The immediate neighbourhood, also, is no less interesting and instructive, and possesses an excellent guide in Mr. Damon's two small and inexpensive volumes.*

2.—" On Some Anomalous Fossils from the Upper Greensand of Cambridge." By Harry Seeley, Esq.

ABSTRACT.

The bodies in question consist of carbonate of lime, with a very slight animal basis. The larger and more common type is in form an elongated sphere, with a single longitudinal wedge-shaped slit, the margins of which are tuberculated; it is granulated, but has one end smooth and flattened. These characters indicate the structures to be Echinodermatous.

* "Handbook of the Geology of Weymouth and the Isle of Portland," and "Supplement," by R. Damon. (London: Stanford. 1860.) In these works, the chief fossils of Portland, and the neighbouring districts, are carefully figured, and a great deal of detailed information about the strata is given; and also a list of the many geological books, papers, and maps, relating to the locality.—Edit.

The specimens might possibly be, therefore, portions of sea-urchins, urchin-spines, joints of the arms of a crinoid, ocular plates of a star-fish, or parasites on Echinoderms. Against all these suppositions, however, there are fatal objections; so that exhausting them one by one, it may be demonstrated that the fossils are not related to *Pedicellariæ*, and that they form no part of any member of the known orders of *Echinodermata;* it therefore follows that they are echinoderms of a new type. On anatomical grounds it is seen that each specimen was not an entire creature. All arguments from anatomy and analogy are opposed to the possibility of a bilateral animal formed of two of the fossils united; whilst there is every reason for believing that several of them (5) must have been grouped round a centre. It may be shown that this was not of a creature of the crinoid kind, and therefore it must have been of one that was free, *i.e.* of a form of starfish. There are several plausible reasons to account for the disc not having been found.

It is believed that ambulatory suckers were protruded through a membrane covering the groove already alluded to. The relative smallness of the groove to the side of the disc is regarded as indicating a concentration of the viscera, as in Brittle-stars.

There are good reasons for excluding them from both the *Ophiuroidea* and *Asteroidea;* while the concentration of viscera will show their near relation to the former order, and the development of feet throughout the length of the groove their close connection with the latter. They would appear to constitute a sub-order of equal value with these two, the whole forming one great order of corresponding importance with the sea-urchins.

A discussion followed the reading of the paper, in which Professor Tennant, Mr. Smith, Mr. Busby, Mr. Bott, and other members took part.

Ordinary Meeting, held at 5, *Cavendish Square, Monday, May* 7th, 1861.

The Rev. Thomas Wiltshire, President, in the Chair.

The following donations were announced :—

"The Geologist." By the Editor.

"Abstracts of Proceedings of the Geological Society." By the Geological Society.

The following gentlemen were elected members of the Association :—

Captain T. D. Baker; * — Cooper, Esq.; Major C. O. Creagh; G. Fleetwood, Esq.; A. G. F. Griffiths, Esq.; Captain T. E. A. Hall; Captain W. E. Lockhart; H. Lainson, Esq.; Captain M. McCreagh; Rev. T. H. Roper; E. L. Savory, Esq.; Major Y. R. Turnbull; Sydney Webb, Esq.; L. M. Woodward, Esq.

Professor Tennant delivered a lecture "On the Geology to be learnt from the Paving-stones of London."*

A discussion followed, in which the President, Mr. Cumming, Mr. Smith, and several members took part.

Mr. Cumming read the following description of the late excursion made by the Association to Reigate :—

On the 9th of last month (April), the members of the Association made an excursion to the cretaceous deposits of the neighbourhood of Redhill and Reigate. The party, accompanied by the President, Professor Tennant, and others, arrived at Redhill at 11 o'Clock, and on being joined by Mr. Bensted, of Maidstone, and also by several ladies from the locality, proceeded to the Fuller's earth beds of Nutfield. The first object of interest which was visited was a pit on the right-hand side of the road, in which was seen a remarkable band of blue clay, about six inches in thickness, asserted by some to be Gault, but by others one of those bands of clay which occur at intervals in the Lower Greensand formation.

About twenty minutes' walk brought the party to the Cockley Pits, where a beautiful section of the blue Fuller's earth is exhibited. This earth

* The printing of this paper is deferred, at the request of Professor Tennant, in order that it may be associated with another lecture to be delivered in the ensuing Session, "On the Geology of the Building-stones of London."

is about twelve feet thick, and is beneath about twenty-five feet of Lower Greensand. So little is the demand at the present time for Fuller's earth, that the proprietor merely works the material out from beneath the stone, and thus long galleries are formed. A number of candles were procured, and several of the members inspected the cave, many points in which proved very instructive. A fine specimen of wood was observed on a slab of the Lower Greensand stone, and specimens of Nautilus and Pleurotomaria were obtained.

The Park pits were then visited. Here the yellow form of Fuller's earth is found, and is worked from the surface. Fragments of very large Ammonites are common, and Nautili are abundant.

The subject of stone for building was discussed, and many important remarks were elicited. It was apparent from the decay of the walls around the Nutfield Schoolhouse, that the greater part of the stone of the Lower Greensand in that immediate neighbourhood is not generally well adapted for building—the fractures in the stone having taken place in every direction, and not only in the line of stratification. There is, however, a fine building-stone obtained in small quantities at no great distance, which has the appearance of fire-stone, and which possesses great durability.

On returning from the pits, the members inspected the collection of Sydney Webb, Esq.

Passing under the Brighton Railway, the attention of the party was directed to the peculiar formation of stalactites from the mortar between the bricks of the arch, several of which could be seen, of about four inches in length. Along the pathways was now observed a coping of stone from the Paludina-bed of the Weald clay, and the position of the bed, from whence the stone is obtained, was pointed out in the distance. The materials of the roads occupied a good deal of attention in passing over Earlswood Common.

The metal of the road is composed of the iron-stone found in the immediate locality, the pits from which it is obtained being scattered over the surface of the common. This stone contains thirty per cent. of iron. From this point, the valley of the Weald was to be seen, stretching far away to the South Downs.

The members lunched, by invitation, at the house of James Nicholson, Esq., after which they proceeded, through Reigate, to the North Downs at

Gatton. From this elevated position could be seen the Gault in the valley, beneath the Greensand ridge, which runs to, and culminates at Leith-hill, where it attains an altitude of 1000 feet. Beyond this is the Weald clay, with the Hastings sands of Tilgate Forest, and on the horizon, the corresponding edges of the upheaved strata, bounded by the lofty hills of the South Downs.

On returning through the town of Reigate to the Redhill station, on the road-side were noticed the beautiful and varied colours of some of the strata of the Lower Greensand formation. These colours are produced by the various stages between the protoxide and the peroxide of iron, with which the strata are charged.

It was moved by Mr. Tennant, seconded by Dr. Richardson, and resolved—

That the thanks of the Association be given to James Nicholson, Esq., of Woodhatch, Reigate, for the hospitality shown by him to the members on the occasion of the late excursion to Reigate.

Ordinary Meeting held at 5, *Cavendish Square, Monday, June 3rd,* 1861.

Professor Tennant, F.G.S., Vice-President, in the Chair.

The following donations were announced:—

"The Quarterly Journal of the Geological Society," and "Abstracts of Proceedings of the Geological Society." By the Geological Society.

A specimen of Rock from the Island of Ascension. By J. Pickering, Esq., Vice-President.*

The following were elected members of the Association:—

Captain Black; J. Hawkins Elliott, Esq.; Captain Kell; Miss. C. S. Percival; James Parker, Esq.; C. Southwell, Esq.

* This Rock, which is very hard, and is supposed to be of recent date, is similar to the conglomerate known as plum-pudding stone, but consists of smaller pebbles, more closely packed together. It contains large quantities of the leathery membranous skins, or shells of the eggs of turtles, together with their unhatched bones. Dr. W. Traill, of the East India Army, by whom the rock was forwarded from the Island of Ascension, states that it is used for grave-stones, and occasionally for building-purposes.

The following papers were read:—

1.—" Notes on the Fossils of the Gault, from the Alice Holt Forest, near Alton." By W. Curtis, Esq.

Every geologist is familiar with the fossils of the Gault, as they are found at Folkstone; but, in inland districts, the knowledge of them, as far as I am aware, is more limited. I have never seen any notice of their occurrence in this district, and was not acquainted with them until the railway-cutting was carried through the Gault of the Holt Forest, in 1847.

The forest of Alice Holt, briefly described by Gilbert White, occupies, probably, about 3,000 acres of land on the widest development of the Gault in the kingdom. It extends over what I take to be the highest point attained by the Gault, an elevation as great as that of the adjoining hills of Malm-rock, and not much less than those of the Chalk.

The Gault is so little exposed that I have never seen a fossil from it in this locality, excepting those I obtained from the railway-cutting. By far the greater part of them consist of nodules, which appear to be of coprolitic origin.* These may be arranged into three groups. In one they are round or oval—outside of a grey colour, but quite black within. These seldom exhibit any trace of organic bodies on their exterior; but I have detected foliations of the septa of ammonites on their fractured surfaces. In another group, which appears to belong to a different species of predacious fish (or Saurian ?), they are more cylindrical and scooped out on one side longitudinally. These generally present on their surface, scales, and, more rarely, vertebræ of small fishes,—sometimes moniliform corals(?); and in one specimen I have observed many small ovoid bodies, presenting somewhat the appearance of *cypridæ*. I have noticed in them traces of *ostreæ*, *inocerami*, and, in one instance, a body resembling turtle-bone. A third

* The bodies which the author here refers to as of coprolitic origin are, in the opinion of many, phosphatic concretions formed around organic bodies, and around *broken casts* of Ammonites, but not necessarily copolitic. The broken casts of Ammonites themselves appear to consist of a similar substance, and must have been washed out of an earlier clay-deposit before they were imbedded in the Gault and coated with the hard calcareous, irony, phosphatic clay of the present nodule. Similar concretions (often more or less *waterworn* on the exterior, just as those of the Gault also are) are found in some beds of the Lower Greensand; also at the base of the Chalk-marl; and the London-clay is also full of similar nodules, both of large and small size. Many of the latter have been washed out and deposited in the Red Crag, and are found in great numbers in the so-called "coprolitic bed" of Suffolk.—Ed.

group is formed of those which contain a small ammonite, or a fragment of a larger one as a nucleus—the organic body exhibiting itself more or less on the exterior. These are all more or less invested with a common coprolitic covering, which, when abundant, approximates them to those in the first group, but which often only very partially conceals the ammonite. I have one large coprolite, contained in a distinct nodule of pale-coloured clay: it is of a black colour, cylindrical, more than an inch in diameter, and, though not perfect, nine inches in length.

Next in abundance to the coprolites are fragments of pentacrinite stems and belemnites. The latter nearly all belong to the same species—they are small and translucent. I have never seen one of these, nor a joint of pentacrinite, in any one of the nodules which I have termed coprolites. Probably more than one species may be detected amongst the ammonites; these are never entire, if exceeding about an inch in diameter.

I have found only two or three fragments of hamite; a few also of some obscure zoophytes and serpulæ. Very few bivalves have been obtained; but fragments of the shell of a species of inoceramus are more abundant, and these are sometimes cemented together by coprolitic matter into small masses. The ostreæ are represented by a few small specimens and fragments of larger ones—in one instance the oyster is adhering to a portion of the shell of an inoceramus.

Amongst univalves I have found only one cirrus, and three of a spiral form, resembling turritellæ; also one small delicate species of spiral univalve elaborately ornamented, which exhibits its cast in a small coprolite. I have obtained only two vertebræ of fish—their length, about half-an-inch, slightly exceeding the diameter. They have no trace of a coprolitic covering. One much smaller vertebra, the length of which scarcely equals half the diameter, appears to have been partially digested, or in some way abraded.

Among the fossils, I find four small fruit-like bodies, hollow and light, resembling in size and form the seeds of the nasturtium.

The Gault appears to be extensively covered by a stratum of yellowish clay, 1½ or 2 feet thick. I do not know whether it be of a diluvial origin, or the Gault itself altered in its colour to that depth by exposure to atmospheric influence. If the former, it is probably identical with a loamy covering spread over the surface of the adjoining Lower Greensand.

The drift-gravel resting on the Gault is composed of broken flint, the prevailing colours of which are white and yellow. The fragments are never rounded, but worn only just enough to take off the sharpness of every angle, and make them feel smooth to the hand. They have a clean washed appearance, no clay being mixed with them.

2.—"Hints for Summer Rambles." By George E. Roberts, Esq.

ABSTRACT.

The author stated the object of his paper to be, to induce the members of the Association to devote some portion of their leisure to the investigation of the geological features of the districts named, which he described as being comparatively little known, even to professed geologists.

Among such districts, he mentioned the Black Mountains, which divide Herefordshire from South Wales, a range showing a very fine exposure of the great conglomerate—the uppermost rock of the old red sandstone. After describing the physical peculiarities of the neighbourhood, he desired to call attention to the rocks, as exhibited in the following near-lying districts.

Unaltered calcite, or carbonate of lime, which occurs in abundance imbedded in the basalt of an erupted dike at Shatterford, near Kidderminster, and which presents a fact of high interest to the chemical geologist, as many important matters hang on the comprehension and adjustment of the intimate connection of a presumed igneous substance with a deposit of purely aqueous formation. He also stated that much good would result from attentive study of the broken and up-cast measures of the great Cambrian system—especially if diligent search is made for any life-remains. At present, the animal history of that remote time is read by the faintest flashes of life-light. Only worm-burrows (*Arenicolites*) and one body-ring of a crustacean, allied probably to *Ceratiocaris*, has rewarded a search through the 30,000 feet of old ocean-deposit, which rest, uptilted upon their edges, like the leaves of a mighty volume, against the volcanic rocks of Caer Caradoc and Church Stretton.

The author then alluded to the black shales of Malvern, whose exact place in stratigraphical position is yet undetermined, and added that, quite lately, M. Barrande, in his attempt to assimilate the Taconic measures of America with the bottom-rocks of Europe, speaks of these identical black shales as being equivalents of those of the Taconic chain—true Cambrian beds. The author further mentioned, that he has lately shown in the

" Geologist" (Vol. iv, p. 102), why the strange shield-bearing fishes of the Old Red should be specially searched for, and stated his opinion that in no rock-measure in the lower divisions of the system will they be searched for in vain.

The condition of the coal-period, whether estuarine, with streams and lakes of fresh water, or a vast area of sea-water swamps, was then mentioned as being yet unsolved. Considerable light has lately been thrown upon it by the published discoveries of Mr. Binney of Manchester; these have been made still more valuable by the endorsement of Mr. Salter. And to enable the matter to be placed beyond a doubt, the author recommended careful investigation of Wyre Forest, in Worcestershire—an almost virgin ground to the geologist; but which contains many fine exposures of plant-bearing shales of the coal-age, and examples of *all the deposits* whose characters will aid us in forming our judgment. The author next spoke of that coal-field with the adjoining basaltic hills of Kinlet, and stated that no one, since the period when Sir Roderick Murchison faithfully sketched out its leading features in the "Silurian System," has taken it in hand to determine—among other questions which wait solution—the relationship existing between its coal-seams and those of the adjoining county of Staffordshire.

The author concluded his paper by a statement showing, that within the limits of a fourteen days' excursion, rocks of the following formation, might be examined in the district he had described, viz.:—the Cambrian, the Lower and Upper Silurian, the Old Red Sandstone, the Carboniferous Limestone, the Permian, the New Red Sandstone, the Lower Lias, the Marlstone, Upper Lias, Inferior Oolite, and the Boulder-drift; together with examples of igneous rock, as Hypersthene, at Kington; Basalt and Greenstone, at Titterstone Clee, Shatterford, Kinlet, and in the Cambrian Sandstone; and Hornblende, Epidote, Augite, Granite, and Syenite, at Malvern.

A discussion followed the reading of the papers, in which Mr. Rupert Jones, Mr. Cumming, Professor Tennant, Mr. Roberts, and others took part.

Mr. Moggeridge exhibited a photograph of some remarkable markings in a sandstone quarry, near Swansea.

The following account of the excursion to Oxford, which had been drawn up by Mr. Badcock, was then read.

In accordance with the circular previously distributed, the members of this Association, under the guidance of the Rev. Thomas Wiltshire, M.A. (the President), and Professor Tennant, visited Oxford, on Monday, the 20th ult., and examined the interesting sections developed at the quarries of Headington and Shotover-hill.

The district chosen for the excursion is one of peculiar interest, on account of the facility which it affords of studying, in a comparatively small space, the complete series of the Oxford, or middle oolites, and portions of the Portland, or upper oolite beds, together with the strata with which they are associated. It has also an additional interest to a young society, from the circumstance of its being the scene of the early labours of the late indefatigable Dr. Buckland, whose name is dear to all students of the science of Geology.

In proceeding eastward from Oxford, which is situate on beds of gravel overlying the Oxford clay (the base of the Oxford oolites), the first indication of the lowest member of the coralline oolite, the calcareous grit, was observed in the bank of the road leading to Headington, accompanied with sandy, or siliceo-calcareous beds, more or less indurated, forming the escarpment of Headington-hill, and of the neighbouring hills surrounding Oxford. In these sandy beds, the largest number of fossils of this formation are found; but from want of time the members were enabled only to give them a passing notice—the *Ostrea gregarea* may be mentioned as the most characteristic fossil.

About one mile further eastward, the company visited the quarry at Headington Windmill, where a good section of the next member of the coral rag, or Oxford oolite (in ascending order), was visible, comprising a ragstone of very marked coralline structure, composed almost wholly of corals. Two or three irregular courses of this stone intervene between the sandy beds previously noticed and the freestone—it is chiefly quarried for walls and road-mending, for which purposes it is extensvely used in the neighbourhood.

Headington quarries were then inspected, where the upper and most important beds of the Oxford oolite were being worked, consisting of a calcareous freestone, in which the oolite structure is clearly visible. The stone is much inferior for building, either to the great oolite (or lowest series), or to the Portland oolites (or highest series of oolites); the colleges and public buildings in Oxford bearing sad testimony to the perishable nature of the material.

Immediately resting on the coral rag, a good section of the Kimmeridge clay was laid open, and several characteristic fossils were obtained by the members; including specimens of the *Ostræa deltoidæa*, several species of Ammonites, portions of *Trigoniæ*, and other fossils more or less typical of the formation. The clay in this, as in other localities, abounds with selenite; and the quarries at Shotover have long been famous for the number and beauty of the crystals found in them, although now much less plentiful than formerly. The argillaceous nodules, irregularly distributed through all the clays of similar character, were observed at these quarries.

The Portland beds which overlie the Kimmeridge clay, and are quarried in the village of Garsington, are not clearly defined at the point visited by the Association, and it is to be regretted that time did not admit of any investigation of this formation, as also of the ferruginous sand, ironstone, and ochre-pits which form the cap of Shotover-hill, and which are referred to the Lower Greensand formation by the surveyors for the Geological Survey, but which are said to include a portion of the Wealden series.

After partaking of luncheon in Oxford, the company visited the New Oxford Museum, through which they were kindly conducted by Professor Phillips, F.R.S., the Curator, who explained to them the most interesting features in the structure of the buildings, and the valuable mineral and fossil collections now located in the Museum. Professor Phillips directed the attention of the Association to a variety of extremely valuable facts, exemplified in the collection formed by the late Dr. Buckland, many of which were of a novel and highly edifying character, and further pointed out all the most important specimens in the collection, bearing upon the history and development of the science of Geology.

By the courtesy of Professor Ackland, M.D., F.R.S., the Radcliffe Library was also opened to the members of the Association, and the collection of foreign marbles which it contains, and which is almost unique, was explained by Professor Tennant.

It was moved by Mr. Cumming, seconded and resolved, that the thanks of the Association be given to Professor Phillips, for his courtesy to the Association, on the occasion of their recent visit to Oxford.

It was moved by Mr. Brain, seconded, and resolved, that the thanks of the Association be given to Professor Ackland, for his kindness in opening the Radcliffe Library to the members on the occasion of their recent visit.

Ordinary Meeting, held at 5, *Cavendish Square, Monday, July* 1*st*, 1861.

Professor Tennant, F.G.S., Vice-President, in the Chair.

The following donations were announced:—

The "Geologists' Magazine." From the Editor.

Specimens of Taranaki Iron Sand. By S. Highley, Esq.

Specimens of Stream Tin. By Professor Tennant.

The following gentlemen were elected members of the Association:—Capt. H. Mangle; J. Rolfe, Esq, F.G.S.; J. Spink, Esq.

The following papers were read:—

1.—"On the Efflorescence which succeeds the action of Heat on certain Sandstones of Yorkshire." By C. Tomlinson, Esq., Lecturer on Science, King's College School, London.

In a short paper, which I had the honour of submitting to the Geologists' Association, on the 7th May, 1860 (*ante*, p. 50), a description was given of the method adopted at Almondbury, in Yorkshire, of hardening sandstone by the action of heat, in order to fit it for a road-metal. The stone stack thus prepared exhibits, in certain states of the weather, a considerable saline efflorescence, so much so, as to change the whole face of the stack in the course of a few hours.

Since the date of my paper, I have submitted a specimen of the fired Almondbury stone to my friend, Professor Bloxam, of King's College, London, who has examined it, and has favoured me with the following note on the subject, which gives completeness to my former statement.

"*King's College, London*,
"25*th May*, 1861.

"Dear Sir,—It may be of some interest to you to know that the Almondbury stone, of which you kindly gave me a specimen some time since, contains, in addition to the silicate of alumina which, of course, constitutes the great bulk of it, a considerable quantity of peroxide of iron, with smaller quantities of lime and magnesia, the latter in larger proportion than the lime. Both potash and soda are also present, in notable quantities, and, contrary to my expectation, the potash predominates considerably over the soda (although I was unable to discover anything but soda in the saline efflorescence, in which it was contained as sulphate).

A small quantity of sulphuric acid (apparently as sulphate of lime and sulphate of soda) was also present, and a minute proportion of titanic acid.

"You will perceive that the vitrifaction of the stone, under the influence of heat, which you noticed in your paper, is fully accounted for by the presence of the above-named constituents, which always confer fusibility upon clays, &c., in proportion to the quantity in which they exist,

"I remain, dear Sir,

"Very truly Yours,

"CHARLES L. BLOXAM."

In connection with this subject I may state, that in some of the recent brick buildings about London an efflorescence forms in considerable quantities. For example, in the railway arch and wall at Kilburn, which are built of red brick, large patches of a white efflorescence may be seen in dry weather, covering the wall, and giving it an appearance as if it had been partially whitewashed. I have observed that this efflorescence is almost entirely confined to that part of the wall which faces the east. In the course of a few minutes I scraped off a considerable quantity of this white substance, and submitted it to Professor Bloxam, who found it to consist almost entirely of sulphate of soda, and that remarkably pure. It is generally stated that these incrustations contain nitre, but, when it is considered that nitrification requires a temperature of from 75° to 90° F., we can hardly look for the formation of nitre in the open air in our cold and humid climate.

2.—"On Science applied to Practical Agriculture." By Lionel M. Woodward, Esq.

ABSTRACT.

The author called attention to the necessity of agriculturists possessing a greater amount of knowledge of the elements of mineralogy and chemistry than is generally prevalent; and he stated that an acquaintance with geology is equally desirable. He treated of the matter, he said, because, as the character of the land governs the system of drainage, the description of stock, and the nature of the crops, so these operations and results ought to be conducted according to the laws of the above-named sciences, rather than by empirical and traditional rules, which were often founded upon false assumptions. Various illustrations of the practical effect of the presence of different soils upon farm-management were given.

In reference to drainage it was mentioned that, in the strong clays of the lias drains are not effective if placed wider apart than fifteen feet;

whilst in those of the Cretaceous formations the distance may be extended to thirty feet; and in those of the more recent strata to wider limits. The depth and direction, as well as the width of the drains, are equally influenced by the nature of the ground.

With respect to the stock, it was remarked that the chalk-downs of Sussex and Hampshire, which are adapted for the rearing of sheep and produce a fine breed, are not so suitable for other animals. Those same sheep, if removed from the chalk-downs and taken to the lias clays of the midland counties, rapidly degenerate; their eyes become dull, their wool lengthens, losing its velvety softness, their fine bone is rendered coarse, and the very grain of the flesh is altered. As a general rule a dry, chalky limestone, or gravelly soil, is beneficial for sheep, while the rich alluvial pastures are most fitted for the heavier kinds of oxen.

With regard to the raising of crops, it was stated that the different divisions of the strata govern the produce; for each of these divisions being composed of certain of the chemical elements in definite proportions, those seeds only can be profitably sown which find in the soil the particular kind of nourishment they require; or which can be made to do so by special manures adapted to the locality.

The author concluded by adducing many errors into which agriculturists had fallen, through neglect of scientific knowledge on these subjects; and he promised, on a future occasion, to embody in a paper the results of sundry experiments upon the connexion between the geological formations and farm-produce.

3.—" On a Deposit of Recent Shells and Bones, in the Cliff of Monk's Bay, Isle of Wight." By Mr. Mark Norman.

ABSTRACT.

The author, after alluding to historical accounts of Monk's Bay, in the eighth century, and to certain evidence which proved that the neighbouring old church of Bonchurch is of a date antecedent to Henry III., mentioned the occurrence of a deposit of large numbers of recent shells of the species *Litorina* and *Patella*,* as well as of bones of the sheep, ox, deer, wild boar, wolf, rabbit, and pig, which is found in the cliff of Monk's Bay, and which exists under the foundations of the old church of Bonchurch. The author stated that he had seen the deposit, in a water-worn

* Periwinkles and Limpets.

gully running from the land into the sea at Monk's Bay, and that is about six feet below the surface of the ground, and under a bed of rolled flints which once formed a road. He had also observed the same deposit in a newly opened grave in the church-yard; it was eighteen inches in thickness, was eight or nine feet below the foundations of the church, and was covered by soil which appeared to have been undisturbed for a very long time, and which did not, in that particular spot, contain human remains.

The author considered there were many difficulties in accounting for so thick a mass of materials over so large a surface—a space that might even be more extensive than that for which there is evidence. He thought the animals, whose bones and shells had been discovered, had been originally used for food. He believed the deposit could not have been caused by the Romans, for it is three feet below the foundations of a Roman encampment close at hand. He imagined, however, it might have been the work of a still more early race; and he grounded his opinion on the authority of the Rev. E. Kell, who, in an article in the *Hants Independent* newspaper, had referred a similar deposit at Southampton to the Celts. It was clear the people had not advanced in civilization, as neither pottery, nor remains of crabs and lobsters—which abound on the coast, and which can be caught with little skill—have been found in the deposit.

4.—"On Worm-Burrowings in some Clays at Bendigo, Australia." By R. I. L. Guppy, Esq.

In some of the mottled red, yellow, and white clays which underlie the gold-deposit, where it appears on the surface, on the flanks of the White Hills of Bendigo, Victoria, a worm-eaten appearance is common. It is like that of wood bored and eaten by the larvæ of certain xylophagous beetles (bostrichus). Cleavage is plainly discernible in this clay; but where the worm-burrowings are crowded it is almost entirely effaced.

The diameter of these worm-burrowings is from one-eighth to one-quarter of an inch, and they are always compactly filled with the excreta of the animals.

Although I stayed some time at the White Hills, I never discovered any creature to which these burrowings could be referred, and I am not aware of any animal likely to produce similar borings.

The surface-soil in the places where this phenomenon occurs is composed of small angular quartz pebbles, and sand, with humus, and contains a greater or less quantity of gold. The clay beneath this is tenacious, and of a dark red colour. As we go lower it gradually becomes mottled with yellow and white, and then passes into a white shaly pipe-clay. Below this is found indurated pipe-clay, which, at a depth of from four or five to ten feet, passes into a clear, white, soft pipe-clay. The whole of the pipe-clay, both the soft and indurated kinds, is laminated by cleavage. It is only in the red and mottled clays that the worm-burrowings occur. I have never found any fossils in any of the beds.

I may point out what seems an evident fact, namely, that these worm-burrows must have been produced subsequently to the formation of cleavage, as the latter is often effaced by them.

5.—" On Geological and Mineralogical Hammers." By Samuel Highley, Esq., F.G.S., F.C.S., &c.

The hammers that are employed by the geologist and mineralogist may be classed under three heads, viz., breaking hammers, picks, and trimming hammers.

Breaking Hammers are used chiefly among the harder rocks, such as are found in igneous, metamorphic, indurated sandstone, and limestone districts. Dr. McCulloch, who, perhaps, had as much experience as any person as to the requirements of a hammer to be used against rocks of this

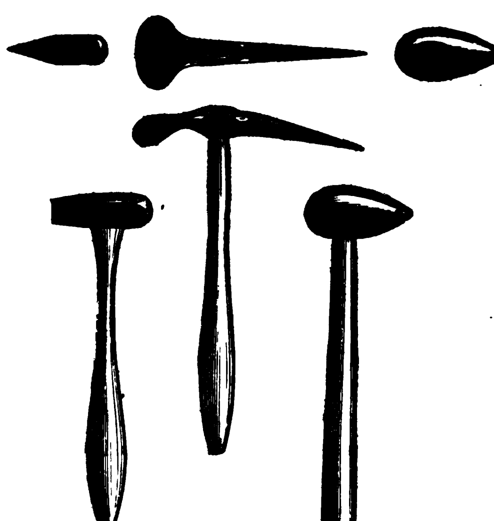


Fig. 1. Fig. 2. Fig. 3.

class, gave preference to a head of spheroidal form with a handle, conical in shape, and tapering towards the iron head—the advantages being, that when a blow is given by a spherical body, *the full* force of the impetus is delivered at *one point* of contact, which is seldom the case when a flat surface is employed, and the conical form of the handle not only prevents it slipping from the hand, when a blow is struck, but rather tends to bed it in.

Some years since I had a breaking hammer made on the model of my trimming or pocket hammer (laid upon the table), fig. 1, the head weighing about three pounds. Experience, however, in the use of this tool leads me to believe that the cutting-edge is of little use, and that a head formed nearly like a duck's egg would be found most serviceable to the geologist; the rounded surface being used for dealing heavy blows against flat surfaces of rock, whilst the conical end is used for breaking open, or splitting off fragments from crevices, the cone being the best form for imparting the full impetus of a blow to a many-sided hole or crack, as it presents *many* points for contact. The head should be made of steel, or iron faced with-steel, and weigh from two to four pounds. The handle should be made of lance-wood, ash, or vine, of the form shown in the larger model (fig. 3).

Picks are of service among sandy, chalky, marly, or clayey formations, the best form being a combination of a pick and a hoe, the hoe being shaped like the bill of the Platypus, but slightly curved; this part of the tool is of great service in clay beds, as it enables the geologist to cut out masses from the size of one's fist upwards, by working round the spot found to contain fossils. The hoe may be made of iron, the pick, which should be about six inches long, of steel; the handle should be of a flattened conical form. A model of this "platypus pick" (fig. 2) is placed upon the table.

Trimming Hammers—such as are used by geologists—are the most useful for ordinary purposes, as they can be carried in the pocket without inconvenience. They are frequently made with one flat striking face, and a wedge-shaped trimming-edge, the edge being either parallel to the axis of the handle, or turned at right angles to it; however, for the reason given, when speaking of "breaking hammers," the striking face should be spheroidal, not flat, to secure the best effects, care being taken that the radius of curvature be not too great, or the form will approach too near to that of the flat-faced head, and will then strike too great a surface of rock at once, and thus part of the force of the blow will be wasted. Most persons prefer the trimming-edge to be parallel to the axis of the handle, and not at right angles to it. Such a hammer (fig. 1) is on the table, and the head is of steel, made entirely from the Taranaki iron-ore, hereafter described (page 165). It is sometimes convenient to have a hammer-head of this kind mounted on a handle made of springy wood, about the length of a walking-stick; a fracturing blow of considerable force can be dealt with such an instrument.

"Cold Chisels," of various sizes, should be used in conjunction with the trimming-hammer, and sometimes also with the breaking-hammers.

In wielding a hammer, one hand only should be used; for, from the crossing or obliquity of the arms, the same velocity or impetus cannot be communicated to the head with two hands as by one.

When a specimen is to be split or trimmed, it should be bedded in the left hand; but the mode of communicating the blow with the right hand is more easily shown than described; it should be borne in mind, however, that it is by the velocity of a small weight, or its impetus, that fragments can be detached without disturbing other parts of the specimen; for this reason Dr. McCulloch recommended that the mineralogist should be supplied with hammers of different weights, weighing from a drachm to two ounces and upwards.

Mineralogists' Trimming Hammers.—Dr. McCulloch gives the following dimensions for a set of hammers, which he recommends should be in the form of rectangular prisms, made of hard steel, the rectangular edges being, in his opinion, more durable than the wedge-shaped heads, and this form presents four trimming edges instead of one:—

	Inches.		Inches.
Length of prism	1½	Side of base	½
"	1¾	"	½
"	1¾	"	⅝
"	2¼	"	¾
"	2½	"	1

Mineralogical Cleavage Mallets.—When the character of the "cleavage" has to be determined in delicate crystals, it is advisable to employ a miniature wooden mallet, in conjunction with a steel-bar, about four inches long by a quarter of an inch square, terminating at one end in a prolonged wedge-shaped edge, so as to form a little chisel. I have found such implements very useful for the purpose indicated, as it allows of very delicate blows being imparted to small crystals.

5.—"Note on the Taranaki Iron-sand." By Samuel Highley, Esq., F.G.S., F.C.S., &c.

Taranaki Iron-sand abounds along a certain part of the coast of New Zealand, a view of which, taken from the Government Report on the late war in that island, is placed upon the table. Sometimes the sand is washed out by heavy seas from between the rocks and boulders, but is soon washed back again on the accession of calm weather, so as to fill up all crevices, and thus make a level beach, formed of this valuable deposit. Sand identical in character is also found *at the base* of Mount Egmont, the extinct volcano, that stands inland about fifteen miles from the shore; thus showing a connection between the two deposits, and indicating a volcanic origin for this iron ore, probably in the shape of volcanic dust, but, as yet, sufficiently exact data for forming a decisive opinion on the geological bearings of the deposit seem to be wanting.

The analysis of the ore by Messrs. Johnson and Matthey shows its composition to be—

Per-oxide of Iron . .	88·45
Oxide of Titanium . .	11·43
Loss	.12
	100·00

On testing the specimen of iron-sand, presented to the Association's collection, with the magnet, it will be found to be powerfully attracted.

The titanium, which imparts such a valuable character to the steel produced from this ore, is indicated in the characteristic lustre of the polished *fused* specimens forwarded for exhibition by Messrs. Moseley, who are at present the agents for Captain Morshed, the gentleman who has obtained a twenty years' grant of the Taranaki Iron-sand from the Government.

The sand is so fine that it readily passes through a gauze sieve of 4,900 holes to the square inch.

A discussion followed the reading of the papers, in which Professor Tennant, Mr. Rope, Dr. Richardson, and other gentlemen took part.

Professor Tennant stated that the Committee had determined upon conducting an excursion to the Isle of Sheppey, on Thursday, the 1st of August.

The following account of the excursion has been drawn up by the courtesy of Mr. S. Highley :—

On Thursday, the 1st of August, about thirty members of the Geologists' Association met at the Victoria and Crystal Palace Stations, and travelled by the London, Chatham, and Dover Railway, across a very picturesque line of country to the Queenborough Station in the Isle of Sheppey, where they were met by the Rev. R. Bingham, M.A., Incumbent of Queenborough, who had kindly offered his assistance in directing the attention of the party to the principal objects of interest on the route that had been selected. Under the joint guidance of the Rev. T. Wiltshire, M.A., President, the Rev. R. Bingham, and Professor Tennant, the party at once proceeded to Minster, where some interesting sculptured tombs and brasses in the old Church were examined, together with some ancient stone coffins.

Leaving these relics, a cold collation was next partaken of at the Royal Oak Inn, at East Lane End, and the members speedily descending the cliff, gained the shore.

Several *septaria* or cement-stones were broken up, and it was seen that they were compounded of four or five-sided columnar masses of argillaceous limestone, with the lateral planes coated with a brownish-yellow crystalline incrustation of carbonate of lime; the fact, also, that a fossil often formed the nucleus of these spheroidal masses, and that beautiful radiating crystals of sulphate of barytes were of constant occurrence on the yellow-calcitic incrustation, was noticed. The septaria *in situ* in the cliffs were then pointed out. Large piles of these stones were observed far down on the shore, where they had been placed ready for removal to the kilns, there to be converted into "Parker's Cement."* The little sand drifts, near high water mark, which abound in the smaller characteristic fossils of that part of the London clay series, were next examined; and a considerable number of examples of Nipadites, portions of Goniaster, Astropecten, and Pentacrinus, Xanthopsis, Teredo, Terebratulina, Solarium, Pyrula, Natica, &c., rewarded the search.

* See "Proceedings," pages 96—98.

Proceeding along the shore, many good and picturesque sections of the London clay, with its capping of yellow gravelly marl presented themselves in the cliffs.

At Hinsbrook, the party mounted to the summit of the cliffs, noting on the way a heap of nodules of iron-pyrites collected, ready for removal to Mr. Hall's chemical works at Queenborough, there to be converted into sulphate of iron.

During the subsequent walk by the edge of the cliff, the effect of one of the many landslips, which are continually occurring on this coast, was well exhibited. A cottage garden was seen far below the level of the adjoining field. It was stated that the cottage, which had formerly stood in the garden, had descended some distance in the course of a night, so gently as not to awake the inhabitants.

The party soon reached Warden Point, where another extensive landslip, near the small church, was inspected. Here, as in the former case, a large plot of land had settled gradually, in the course of a few hours, and so quietly, that large trees are still standing upright, as described in the Rev. R. Bingham's paper "On the Geology of the Island of Sheppey," at page 92—3 of our "Proceedings."

From this spot, which commands a fine prospect of the opposite coast of Whitstable, Herne Bay, Reculver, with Margate in the extreme distance, the cliffs rapidly decrease in height towards Shellness Point, where they terminate. The members, after descending again to the shore, viewing the landslip from its base, and securing crystals of selenite, or "Quarry Glass," as this mineral is locally called, retraced their steps to Warden, and, having purchased fossils of the cottagers at Mud Row, recrossed the island to Queenborough Station, from whence they returned to London, having in a few hours made an inspection of the principal features of Sheppey, which but a few years since could not have been accomplished under three days.

The Committee propose next Summer conducting excursions to Cambridge, Hastings, Harwich, and Lewes.

The next meeting of the Association will take place at their Rooms, 5, Cavendish Square, on Monday, 4th November.

Members changing their address, or intending to forward papers during the ensuing Session to the Association, are requested to communicate with the Honorary Secretary, at 5, Cavendish Square, London, W., at their earliest convenience.

The work on the "British Cretaceous Echinidæ," by Mr. E. Cresy and the Rev. T. Wiltshire, which was mentioned in the last number of the "Proceedings," is in progress, and will be shortly printed,

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

No. 8.] [Session 1861-2.

Ordinary Meeting, Monday, November 4th, 1861.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following were elected members of the Association:—Miss Perceval; James Atkinson, Esq.; J. H. Bass, Esq.; John Carpenter, Esq.; Thomas Fawell, Esq.; Parker William Freeland, Esq.; W. Harvey Moberley, Esq.; Col. O'Connor; John Parkinson, Esq.; G. T. Saul, Esq.; Thomas Sopwith, Esq., F.R.S.; Capt. Y. S. Swann; James Vavasseur, Esq.; William Vicary, Esq.; James H. S. Wildsmith, Esq.

The following donations were announced:—

Address to the Geological Section of the British Association, at Manchester, 1861, by Sir Roderick Murchison, F.R.S., &c. By the Rev Thomas Wiltshire, President.

Synoptical Table of British Aqueous Rock Groups, by Professor William King. By the Author.

Notes on Cambridge Palæontology, Parts I., II., and IV., and Notice of Opinions on the Stratigraphical Position of the Red Limestone of Hunstanton, by Harry Seeley, Esq. By the Author.

The Mansfield Copper-slate Mines in Prussian Saxony, their Past and Present State, by W. P. Jervis, F.G.S. By the Author.

The Quarterly Journal of the Geological Society, No. 67. By the Geological Society.

The Geologist Magazine, Nos. 43, 44, 45, 46, and 47. By the Editor.

On the Lavas of Mount Etna, by Sir C. Lyell. By J. Y. Johnson, Esq.

On the Silurian Anthracite of Cavan, by J. J. Whitby, LL.D. By J. Reynolds, Esq.

Report on the Coal-District of the Northern Part of the County of Dublin, by J. J. Whitby, LL.D. By J. Reynolds, Esq.

A considerable number of Fossils from the Crag, Chalk, Upper Greensand, and Lias. By Mr. Mark Norman.

The following paper was read:—

On "Coal; its Geological and Geographical Position." By Professor J. Morris, V.P.G.S., &c.

Among the various natural substances used in commerce and the arts, few are more important and interesting than Coal. Whether we view it, on the one hand, in relation to the influence that it has had upon the progress of civilization, and in contributing, directly or indirectly, to the comforts and luxuries of life, or, on the other hand, in a scientific point of view, as to its nature, origin, and position, coal must always be a subject demanding careful consideration. In England alone, between 70 and 80 millions of tons of coal have been raised during the past year, employing about 250,000 persons, who, together with their families, will probably represent one million of people dependent on this branch of mining industry; the wages for raising the coal amount annually to more than £12,000,000. The estimated produce of British coal in 1860 was 80,042,698 tons, besides 4 millions of waste in fire-heaps. Of this, Scotland yielded 10,900,500 tons, and Ireland 119,425 tons. This amount of coal was raised from about 3,000 collieries, of which England and Wales have 2,509, Scotland 427, and Ireland 73. The following table shows the proximate quantity and value of coal and mineral produce in 1860:—*

* "Mining Records for 1860; Mineral Statistics," by R. Hunt.

	Quantity.	Value.	Total Value.
	Tons.	£	
Tin Ore	10,462	748,827	
Copper Ore	236,696	1,507,133	
Lead Ore	89,081	1,236,749	
Silver Ore	125	2,439	
Zinc Ore	15,552	39,631	Metals. £6,102,016
Pyrites	135,669	84,139	
Arsenic	1,600	12,800	
Nickel	6	254	
Tungsten	19	19	
Manganese	932	3,096	
Iron Ore	8,024,205	2,466,929	
Salt	1,570,972	589,144	
Clay	508,666	221,150	Other substances. £880,913
Barytes	13,354	9,750	
Coprolites	30,000	60,000	
Sundries, Ochre, &c.	597	869	
COAL	80,042,698	20,010,674	Coal. £20,010,674

From the above table it will be seen that the estimated value of this produce of coal is about two-thirds of the annual produce of the metalliferous and other mineral substances raised in the British Isles.

Of the coal raised, about 10 million tons are annually consumed for gas-making, 15 million tons for the production of iron; and from 6 to 7 million tons are exported to foreign countries. Deducting the amount exported, it may be roughly calculated that Great Britain uses about 2,500 tons for every 1,000 inhabitants; while Belgium consumes 1,200 tons for 1,000 inhabitants; Prussia, 470 for 1,000; and France, 350 tons for every 1,000 inhabitants. The coal exported to foreign countries necessarily employs a large number of persons for the shipment and conveyance of the same.

The following summary gives the coal-exports of the United Kingdom for 1860,* from the districts mentioned:—

Northumberland and Durham - -	3,756,162
Yorkshire - - - - - - -	260,182
Lancashire - - - - - -	590,128
Bristol and South Wales - - -	1,739,260
Scotland - - - - - -	442,328
Total quantity - -	6,788,060 tons.

* "Mineral Statistics for 1860," by R. Hunt, p. 151.

The quantity of coal imported into the Port of London for the last five years is as follows:—*

	Ships.	Seaborne.	Railway.
		Tons.	Tons.
1857	10,444	3,133,459	1,206,775
1858	10,603	3,266,446	1,190,521
1859	10,693	3,299,170	1,191,169
1860	11,226	3,573,377	1,477,545
1861	10,765	3,550,315	1,642,502

In addition to the above, 18,217 tons were brought by canal in 1861, making a total of 5,211,034 tons for that year.

For convenience, we may arrange our observations under three heads, viz.,—Where is coal? What is coal? What was coal?

Most persons conversant with the elementary principles of Geology are aware that, although the different materials constituting the crust of the earth have, at first sight, an apparently irregular distribution, these materials really occur in a regular and definite order, or succession, one above the other. Although some members or strata may occasionally be wanting, still the general sequence remains the same. The stratified rocks are divided, according to their age, into primary, secondary, and tertiary; or, viewed as indicative of life-periods, into palæozoic, mesozoic, and cainozoic. Although, as it will be hereafter shown, coal has been formed at different periods, and occurs at more than one geological horizon, yet the principal coal-strata of the northern hemisphere, *i.e.*, Europe and North America, those which principally concern ourselves, belong to the upper part of the palæozoic series of strata.

STRATA FORMED DURING THE PALÆOZOIC PERIOD.

Upper:
- Permian.—Marine remains and land plants.
- Carboniferous.—Marine remains and land plants:—good coal.
- Devonian.—Marine remains and land plants. (Old Red Sandstone: fresh-water?)

Lower:
- Silurian.—Marine remains; traces of carbonaceous deposits.
- Cambrian.—Marine remains.

* The above returns have been kindly furnished by J. R. Scott, Esq., of the Coal Exchange, London.

The carboniferous strata are, however, further subdivided, according to the nature and character of the materials composing them. They may be classed under three principal varieties, as dependent on their organic, chemical, or mechanical origin.

1st. Carbonaceous.—The beds of coal, presenting different varieties (ranging from the ordinary anthracite to the more or less bituminous coals), resulting from chemical changes of an ancient vegetable matter.

2nd. Arenaceous and argillaceous.—These strata are of mechanical origin, and consist of conglomerates, coarse grits, coarse and fine sandstone, clays, and shales, as seen in the millstone-grit, and the shales, clays, and sandstones of the coal-measures.

3rd. Calcareous.—Limestones, either pure, argillaceous, or magnesian; sometimes almost entirely composed of organic exuviæ. They indicate strata chiefly formed by chemical and organic agency. The beds of limestone are of various thicknesses, and contain remains of marine animals.

To these may be added beds or layers of siliceous concretions (chert or pthanite), and nodules or bands of ironstone.

The carboniferous group presents, in descending order,—

Origin of the Strata.	Name.	Nature of the Strata.
Mechanical, organic, and chemical.	Coal-measures.	Alternations of shale, clay, sandstone, and COAL, with occasional bands of ironstone, and limestone, varying from 2,000 to 12,000 feet.
Mechanical.	Millstone-grit.	Coarse grits and sandstone, with layers of shale, and sometimes COAL, containing land plants, and a few marine shells; thickness, 100 to 800 feet.
Chemical and organic.	Mountain-limestone.	Sometimes argillaceous and magnesian, of different colours, containing numerous marine remains. Sometimes with COAL. From 200 to 2,000 feet.

Coal, therefore, is a stratified rock, and is not found in veins or fissures, like metallic minerals, but occurs in numerous and regular beds, alternating with sandstone and shales, and varying in thickness from a few inches to 30 feet, as in Staffordshire; or nearly 70 feet, as in the Mauch Chunk seam in North America.

The sequence above given is the usual one for the carboniferous series; but there are localities where the grit and limestone are wanting, and the coal-measures immediately repose on the silurian rocks, as in parts of Shropshire, and at Dudley in Worcestershire. The normal condition of the carboniferous rocks undergoes, however, a remarkable and interesting change as the series is traced from the South of England to the North, through Yorkshire, Derbyshire, and Cumberland, into Scotland. In the southern districts, coal is restricted to the coal-measures proper; and the millstone-grit and limestone consist of tolerably uniform and undivided masses of great thickness. In proceeding northwards, through the midland counties, to Yorkshire, Cumberland, and Northumberland, the millstone-grit and part of the limestone series become much subdivided, and contain interstratified beds of coal. In Scotland these changes are still further extended, and the limestone is interlaminated with other sedimentary beds, as shales, clays, ironstone, sandstone, and many seams of coal; so that the coal-fields of Scotland belong chiefly to the lower part of the carboniferous system,—to the age of the limestone, which in middle and southern England is nearly undivided, or at least underlies the principal coal-bearing strata. The Scottish coal-fields in this respect present some analogy to the coal-fields of Southern Russia.

Geographical Distribution.*

Coal in Great Britain and Ireland is somewhat unequally divided, and does not always bear a relative proportion to the extent of the carboniferous system. Thus in Ireland, the lower member—the mountain-limestone—is largely developed, occupying two-thirds of the whole area; but the coal-bearing areas are comparatively limited, and are estimated at about 200 square miles.

These are, in North Ireland, the coal-fields of Leitrim, Fermanagh, and Armagh; in South Ireland, coal-seams occur in Limerick, Clare, Tipperary, Queen's County, Carlow, and Cork. The coals of the north (Ulster and Connaught) are chiefly bituminous; those of the south (Leinster and Munster) are more anthracitic.

The Leinster coal-field of Kilkenny, Queen's County, &c., has the

* A large amount of information on this subject is to be found in Taylor's "Statistics of Coal," and in E. Hull's "Coal-fields of Great Britain."

largest number of collieries. The Munster district—Cork, Tipperary, Kerry, &c.—contain also beds of anthracite, but not of great thickness.

The Scotch coal-fields comprise an area of from 1,500 to 1,700 square miles, and occur in Clydesdale, Mid-Lothian, Fifeshire, Clackmannan, Ayrshire, and Lesmahago. The millstone-grit is represented by the sandstone at Roslyn and elsewhere. This is interstratified with shales, fossiliferous limestone, and some coal-seams. The mountain-limestone is so much modified in this district by the intercalation of shales, sandstones, ironstones, and numerous coal-seams, that it constitutes a great and productive lower coal-series.

Lanarkshire, Linlithgow, and Fifeshire yield large quantities of parrot or cannel coal, as well as household coals. The celebrated Black-band Ironstone of Airdrie is one of the many rich ironstones of this district.

As an example of the Scottish coal-fields, especially with reference to the differences they present to the features of those of the South, the following classification (by Mr. Geikie) of the Edinburgh and neighbouring coal-fields, deserves attention.

	Feet.
1. Upper coal, or flat coal series, consisting of sandstones, shales, and coal. (Lower part of the coal-measures of England.)	1,800
2. Moorstone rock, or Roslyn sandstone; gritty, thick, white, and reddish sandstone. (Millstone-grit.) . . .	1,500
3. Lower coals and upper limestone; alternations of sandstones, shale, and coals, with beds of crinoidal limestone—including the black-band ironstone and parrot-coals. (Yoredale series.)	900
4. Lower or thick limestone, consisting of bands of crinoidal limestone, with interstratified shale and sandstone, and one or two seams of good coal. (Scar limestone.) . .	200
5. Lower carboniferous or calciferous sandstone, with some shales and numerous thin limestone bands. (Equivalent perhaps to the "carboniferous slate" of Ireland.)	

The total area of the English and Welsh coal-fields is estimated at between 2,700 and 3,500 square miles.

Durham and Northumberland, having an area of about 700 square miles, with about ten seams of workable coal, collectively making 36 feet of coal. Of this there are several varieties adapted for household-purposes, for furnaces, for gas-making, and for the steam-navy.

Cumberland has an area of 25 square miles of coal-field; its average thickness of coal is 15 feet.

The Lancashire coal-field has an area of about 230 square miles, with an average thickness of 60 feet of coal. This coal-field yields house-, furnace-, and especially cannel-coals, also some iron-ore. These coal-measures of Lancashire are divided into upper, middle, and lower. The lower or ganister coal-beds, have shaley roofs, containing marine shells, like the equivalent strata of Yorkshire and Derbyshire.

In the two last-named counties there is an area of about 760 square miles of coal, with an average thickness of 46 feet.

In South Staffordshire, the area of the coal has been 97 square miles; its average thickness 48 feet. Here large quantities of ironstone are still raised (825,000 tons in 1859).

As another example of coal-areas, we may mention that of South Wales, having an extent of more than 900 square miles, and presenting the enormous thickness of from 10,000 to 12,000 feet of strata, comprising 84 feet of workable coal, and yielding a vast supply of ironstone (producing 985,290 tons of iron in 1859).

SOUTH WALES COAL-FIELD.

Coal-measures, 10,000 to 12,000 feet.

Millstone-grit, 300 to 400 feet.

Carboniferous limestone, 1,000 to 1,500 feet.
Lower shales and limestone, 400 to 500 feet.

LANCASHIRE COAL-FIELD.

Coal-measures (upper, middle, and lower), 6,000 to 7,000 feet.
Millstone-grit (with shale and thin beds of COAL), 3,000 feet.

Yoredale limestone (and shales), 2,000 feet.
Scar limestone.

YORKSHIRE COAL-FIELD.

Coal-measures (upper, middle, and lower), 2,000 to 3,000 feet.
Millstone-grit (with shale and COAL), 300 to 700 feet.
Yoredale limestone (with flagstone, shale, and COAL), 300 to 1,000 feet.
Scar limestone (with beds of shale, grit, &c., in the North; nearly undivided in South Yorkshire), 400 to 1,000 feet.

DURHAM AND NORTHUMBERLAND.

Coal-measures, 1,500 to 2,000 feet.

Millstone-grit (with shales and COAL), 400 feet.
Yoredale limestone (with shale, sandstone, and thin COAL), 500 feet.
Scar limestone (with shales and COAL-SEAMS), 1,000 feet.
Tuedian limestones, sandstones, and shales, 1,000 feet.

Table of the Proximate Area of the Coal-fields in England and Wales.

Compiled from Taylor's "Statistics of Coal;" the Mining Records for 1861; and Hull's "Coal-fields," 1861.)

Coal-fields.	Area in square miles.	Workable Seams.	No. of Collieries.	Average thickness of Coal in ft.*
Northumberland and Durham	700	10	268	36
Cumberland	25	6	28	15
Cheshire	..	..	31	..
Lancashire	230	13 to 18	359	60
Flintshire	33	5	40	25
Denbighshire	47	7	39	30
Anglesea	9	5	5	25
Derby and Yorkshire	700 to 1,000	15	544	40
Leicestershire	15 to 40	10	14	13
Shropshire	28	6	55	27
North Stafford ..	75 to 90	22	125	94
South Stafford ..	93	..	438	45
Warwickshire	30	8	16	26
Forest of Dean ..	34	..	62	24
Somerset	45 to 150	20	35	75
South Wales	900	25	325	84

From the above it will be seen that the distinct three-fold division of the carboniferous group in southern England is considerably modified in the northern and Scottish districts,—coal, which is restricted to the upper measures in the former area, occurs also in the lower or limestone series of the latter or northern area. Thus the almost undivided mass of mountain-limestone in the southern, and even central, counties becomes, in Northumberland (where it occupies nearly the whole of the northern part of the county), a complex group, consisting of alternations of sandstone, shale, ironstone, coal, and bands of limestone, with marine remains. The thickness of this group is estimated at 2,500 feet (Tate), or about 3,500 feet (Boyd). Twenty coal-seams have been recognized; one-half of them, having an average thickness of 30 feet, are workable, but the coal is

* The coal-seams of less than 2 feet thickness are not included in this estimate. These smaller seams are very numerous, and, if reckoned, would greatly augment the proportional thickness of the coal.

generally of inferior quality, although some seams yield a good coal—as that at Shilbottle, also the Cooper Eye and Bulman coals.*

Beneath these beds is the Tuedian group of Mr. Tate, about 1,000 feet thick, and consisting of shales, slaty and calcareous sandstones, thin beds of argillaceous limestone and chert, with remains of plants, but no workable coal.

Prof. Phillips long ago pointed out the important facts connected with this subject in his careful survey of the mountain-limestone series of Yorkshire, and showed that "the calcareous members of the Yoredale series have their maximum towards the east, the argillaceous beds towards the south and south-west, and the grit rocks towards the north and north-west."† And, further, that "the agencies concerned in producing the mill-stone series were not geographically posited like those which occasioned the grits and shales of the Yoredale rocks."‡

Similar phenomena have been observed in the Appalachian coal-region of the United States. Prof. Rogers has established the interesting fact, from the surveys of Pennsylvania and Virginia, that the rocks of mechanical origin are invariably coarsest and most massive in the south-east, and become more fine-grained and arenaceous as they are traced towards the north-west, and undergo a corresponding reduction in thickness, while some thin quite away. Thus the great coal-conglomerate, which is nearly 1,000 feet thick in Sharp Mountain, is only 300 feet in the Wyoming basin, thirty miles to the north-west. Again, in the basins north-west of the Alleghany Mountains, it rarely exceeds 80 to 100 feet, while in Western Pennsylvania, Ohio, and Kentucky, it dwindles to a thin bed of sandstone, with a few pebbles, its thickness being only 20 to 30 feet. The limestones and other marine deposits also afford evidence of gradation, but in a different manner. Thus the limestones of the coal-measures of Pennsylvania, Virginia, and Ohio, gradually augment in a westerly direction. Throughout the south-east basins, comprising the anthracitic coal-fields of Pennsylvania, there is a total absence of limestone; but, as we cross the basins to the west, the limestone gradually increases in

* G. Tate, Proc. Berwickshire Naturalists Club, 1858. E. F. Boyd, Trans. North England Institute of Mining Engineers, vol. ix. p. 186.

† Geology of Yorkshire, 1836, vol. ii. p. 184.

‡ Ibid., p. 190. See also Hull's Coal-fields of Great Britain, 2nd Edit., p. 250; and Sorby, on the Millstone-grit of Yorkshire.

thickness, until at Wheeling it is about 200 feet. The two series present a marked difference, the sandstones decreasing in the direction in which the limestones increase in thickness.*

Mr. Hull has pointed out an interesting fact bearing on the above, namely, that the coal-measures proper of England are gradually attenuated in a south-easterly direction. In compa ring the relative thickness of the carboniferous series of Lancashire with those of Leicestershire, he shows that the former has an estimated thickness of 12,300 feet, whilst in the latter area it attains only 2,575 feet.†

In Europe there are wide coal-fields, but not of the same extent as those of Great Britain. In Belgium and northern France, much disturbed carboniferous strata occur, with numerous thick coal-seams.‡ Coals for house, forge, and gas, are abundant, and also anthracite (especially in the lower beds). The Belgian area has been estimated at more than 500 square miles. The coal-area of France has been calculated at 1,000 square miles; but it is probably more extensive, and comprises sixty-four separate coal-fields (one-half only being important), which occur in forty-five of the departments, the united thickness of workable coal amounting to about 12 yards. The *northern* group includes the coal-fields of the departments of the Nord and Pas-de-Calais; the number of coal-seams is between 70 and 80; they are highly inclined, but their extent and depth, especially in the northern limits of the basin, are not known. The coal raised in 1858 was 1,800,000 tons. The *central* group comprises the coal-fields of the Loire, Saône-et-Loire, Haut-Loire, and Puy-de-Dôme and Allier. This is the most important of the three groups, both as to extent and nature of the coal (comprising free-burning, smithy, non-caking, and other varieties), the basins of the Loire and Saône-et-Loire being most largely worked. In the latter basin, at Blanzy, there are two beds from 10 to 15 yards thick, and even more at Creusot and Montchanin. The basin of the Loire contains the greatest thickness of coal, and is the chief scene of industry. In it are situated the mines of Rive-de-Gier and St. Etienne, where the

* H. D. Rogers' Geology of Pennsylvania, vol. ii. p. 797. A most valuable work on the general subject of coal-formations and the conditions under which they were accumulated.

† Coalfields, 2nd Edit. p. 251.

‡ Dufrènoy and Elie de Beaumont, Carte Géologique de la France. M. A. Dumont, Carte Géologique de le Belgique.

united thickness of the seams is about 45 yards; the best coals are obtained from this basin, and are largely used for the manufacture of pig and malleable iron; also a highly bituminous or gas coal, resembling cannel, is worked at Littes, near St. Etienne. Including some smaller coal-lands, the central group yielded, in 1858, nearly 3,000,000 tons. The *southern* group embraces the coal-fields of the departments Gard, Garonne, Hêrault, and Lot. The basin of the Gard is the most important, the coal having a mean thickness of 17 yards, and extending over 70,000 acres. The principal mine is at Grand-Combe. Near Alais a hard coal, used for metallurgic purposes, is worked. From this group 750,000 tons of coal were extracted in 1858. Anthracite is obtained in the departments of the Sarthe, Mayenne, Isère, and Maine-et-Loire.* One-half of the coal consumed in France is supplied from England, Prussia, and Belgium.

Tertiary lignite in France is principally worked near Fuveau, in the Bouches-du-Rhone,† and is chiefly supplied to Toulon and Marseilles, where it averages 14s. 6d. per ton.

Besides these fossil fuels, France possesses considerable beds of peat and turf, the area of the peat-bogs (tourbières) being estimated at nearly 1½ million acres, yielding 500,000 tons annually, and are principally worked in the valleys of the Somme, Seine, and Lower Loire; but it occurs in many of the departments, and employs a large number of persons for its extraction.

In the Swiss Alps the coal-measures are represented by anthraciferous schists, highly modified by metamorphic and mechanical agencies.

In Rhenish Prussia there is coal worked between Saarbruck and Kreutnach, having an area of 900 square miles. Westphalia yields coal in the valley of the Ruhr.‡ Saxony, Silesia, Poland, and Bohemia,|| have productive coal-measures, yielding iron also. The basin of Rakonitz is the most extensive in Western Bohemia.

The coal-measures of Poland overlie the mountain-limestone, and are

* Géologie Appliquée, by M. A. Burat, 1858; and Morning Chronicle, June, 1860.

† Edin. New Phil. Journ., vol. vii. p. 287.

‡ Murchison and Sedgwick, Trans. Geol. Soc., 2nd Ser., vol. vi. p. 228.

|| M. Chevalier, Sur les richesses de la Bohème en combustible fossiles, Ann. des Mines, 1842, tom. i. p. 575.

worked at Sierza, Dombrova, and Bendzin, the coal at one place being near 60 feet thick, but not of good quality throughout. These strata are continued into Lower Silesia. The coal-field of Upper Silesia, near Breslau, contains seams of fair quality.*

Valuable deposits of coal exist in Styria, and are worked at Buchberg, near Cilli; it resembles anthracite, burns with very little flame, and produces no cinder;† it is not of palæozoic age.

In Spain there is the great coal-field of Asturias;‡ and coal is obtained at Vallongo, in Portugal.||

Coal-fields occur in Southern Russia, belonging to the lower carboniferous series, especially on the Donetz. The area occupied by the carboniferous rocks between the Dneiper and Don is estimated at not less than 11,000 square miles, containing anthracite in the western and bituminous coal in the eastern part; the richest portion is in the north-eastern district at Upensk and Lissitchia-Balka, where the united thickness of the coal is 30 feet, the limestone 50 feet, the grits, &c., 200, and the argillaceous beds 600 feet.§ In Central Russia coal is also found in the Valdai hills, the Moscow basin, Kaluga, &c.; the coal is light, impure, and pyritous, and is more like tertiary lignite than the old bituminous coal;¶ it also contains mellite, a mineral found hitherto in the brown coal of Artern, Thuringia,** and of Bohemia.

In Asia Minor coal-measures have been worked at Heraclea, on the Black Sea.†† Of the old coal-measures traces seem to be lost in Asia,

* Murchison, Russia in Europe, vol. i. p. 651.

† T. Y. Hall, North of England Institute of Mining Engineers.

‡ Mines de carbon de piedra de Asturias, Madrid, 1831: Schulz, Resena geognostica del principado de Asturias: Paillette, Bull. Soc. Géol. France, Sér. 2, vol. ii. p. 430.

|| D. Sharpe, On the Geology of Oporto, &c. Quart. Jour. Geol. Soc., vol. v. p. 145.

§ Murchison, Geology of Russia, vol. i. pp. 90, 104, 112. M. A. Demidoff, Voyage dans la Russie Méridionale. Kovalerski, Gornoi Journal, 1829.

¶ Russia in Europe, vol. i. p. 78. I have examined this coal, through the kindness of my friend Mr. A. Tylor, who obtained specimens during his recent visit to Moscow. It is light, of a brown colour, leafy structure, burns easily, giving an empyreumatic odour.

** Auerbach and Trautschold, Ueber die Kohlen von Central Russland, 1860, Nouv. Mémoires Soc. Imper. des Naturalistes de Moscou, vol. xiii. p. 29.

†† Poole, Journ. Geol. Soc., vol. xii. p. 3.

until we come to China, where coal has been long raised; but we know little of its true geological position: it has been worked in deep pits near the city of E-u,* but it is not bituminous; also at Tingtih, on the Pe-kiang river, on the Yang-tse near Whan-shih-kang,† and beyond Süchow, and in the province of Hoonan.

In Australia (Sydney and Victoria) and Tasmania (South Esk and Jerusalem basins) coal occurs associated with palæozoic strata; in the latter country it is both anthracitic and bituminous.‡ The localities for the latter are the Mersey and Don rivers, north side of the island; Kingston, Fingal, Break-o'day, Douglas River, Schouten Island, and Prossers Plains, on the east coast; at Jerusalem, Jericho, Springhill, Green Ponds, and Hamilton, on the southern side. Anthracite has been found at Adventure Bay, Long Bay, Recherche Bay, and near Hobart Town.||

Area in Square Miles of the Principal Coal-fields of Europe.

France	1,000	Saxony	30
Belgium	510	Spain	200
Saarbruck	960	Russia	100
Westphalia	380	Great Britain	5,430
Bohemia	400	Ireland	150

North America has the widest and richest old coal-measures in the world. In the British possessions are the coal-fields of Newfoundland, New Brunswick, and Nova Scotia (including Sydney, Pictou, Cape Breton, &c.), altogether occupying more than 7,000 square miles. The latter district presents an upper coal-series of 3,000 feet thickness; a middle series containing valuable coals and ironstones, 4,000 feet; and the lower carboniferous, with gypsum, &c., 6,000 feet. The great carboniferous formation of the United States occupies altogether nearly 200,000 square miles, and is divided into the Appalachian, the Illinois and Indiana, the Missouri and Arkansas, the Michigan, and the Texas basins. To illustrate a striking feature of this great coal-series, I may mention that one seam, the Pittsburg seam, extends over an area of 14,000 square miles. In the western and central areas the coal-seams are nearly hori-

* Cobbold, Quart. Jour. Geol. Soc., vol. xii. p. 358.

† Lord Elgin's Mission to China, vol. ii. p. 389.

‡ Strzelecki, Physical Description of New South Wales, 1845, pp. 123, 126, Selwyn, Quart. Jour. Geol. Soc., vol. xvi. p. 145. Clarke, ibid., vol. xvii. p. 354.

|| Milligan, Jour. Soc. Arts, vol. ix. p. 387.

zontal, and bituminous; but to the east they become, with the other strata, very much contorted, as they rise up into the Alleghanies, and here they take on the anthracitic character.

*Area of the Principal Coal-fields of North America in Square Miles.**

Appalachian basin	55,500	Michigan	13,350
Illinois, Indiana, and Kentucky	51,100	Texas	3,000
Iowa, Missouri, and Arkansas	73,913	British Provinces	7,530

The upper palæozoic series includes, besides the carboniferous, the permian rocks; and in these fossil fuel and other carbonaceous substances are not unknown, as in Russia, Saxony, and Spain.

Having thus noted the chief points relating to the distribution of the old or palæozoic coal—that of the real carbonaceous system, I will refer briefly to the coals and lignites of younger deposits.

In the British Isles we have coals of the oolite period in the Isle of Skye, at Brora in Scotland,† and in the moorlands of Yorkshire.‡ The lignites of Woolwich and Lewisham, near London, belong to the lower eocene; and to this period are referable the lignites of Soissonais and elsewhere in the Paris basin. To the upper eocene (or miocene) may be referred the lignite of Antrim, that of Bovey Tracey ‖ (Devon), and Corfe (Dorset). To the same age belongs that more extensive series of deposits well known as the brown coal of Germany, Silesia, Bohemia, &c., supplying some household-fuel, and often indeed presenting a very compact and coal-like structure, more often woody lignite, occasionally jet-like, and sometimes semibituminous, with the woody structure nearly obliterated. This remarkable fossil fuel contains retinite, or fossil resin; it yields also numerous animal and vegetable fossils, and its associated shales are frequently worked for alum, as at Altzattel, in Bohemia. Lignites occur extensively in Hungary§ and Austria.

At Sarzanello in Piedmont, at Castiani in the Maremme, and at Monte Bamboli in Tuscany, the Italians obtain both anthracitic and bituminous

* H. D. Rogers, Geology of Pennsylvania, vol. ii. p. 1015.

† Murchison, Trans. Geol. Soc., 2nd. Ser., vol. ii. p. 293.

‡ Phillips, Geol. Yorkshire, vol. i. p. 173.

‖ Milles, Phil. Trans. 176, vol. li. p. 534; Key, Quart. Journ. Geol. Soc., vol. xviii. p. 9.

§ Beudant, Voyage en Hongrie, vol. ii. p. 406.

coals These are referred to the miocene age, and they contain remains of *Anthracotherium*, tortoises, and exogenous leaves.*

Coal-mines have also been successfully worked for many years at Valdagna, in Venetia, yielding a coal useful for factories and steam-mills, but not producing gas.†

Lignites of probably miocene or pliocene age occur in patches in Asia Minor, Syria, Persia, &c.‡

Other lignites and coal, probably tertiary, and some of them of commercial importance, occur at Disco Island, Omanekfiord, and Wygat on the western coast of Greenland. The surturbrand of Iceland is said to be of miocene age. Coal and lignite, possibly of tertiary age, and of great extent, occur on the Mackenzie River,|| and along the eastern side of the Rocky Mountains, as far as the Saskatchewan River. There is also coal at Jameson's Land and Melville Island,§ and in Oregon;¶ but the age is doubtful.

Tertiary lignite is found in the Souri valley,** in thin layers of a deep brown colour, presenting different varieties, friable, compact, and some resembling bituminous coal; other portions are like charcoal.

On the Colorado River and a tributary of the Del Norte, lignite-coal has been observed in beds about a foot thick, of good workable quality.††

Bituminous coal is procured from two beds, varying from 5 to 7 feet in thickness, near Nanaimo, Vancouver's Island, and is chiefly used for domestic and steam purposes; it varies in structure, and contains retinite.‡‡ At Bellingham Bay (Washington), similar coal-bearing sandstones occur.||||

There are other lignites in North America, useful at least for distillation

* Jervis, Quart. Jour. Geol. Soc., vol. xvi. p. 485.

† Jour. Soc. Arts, vol. ix. p. 130.

‡ Quart. Journ. Geol. Soc., vol. xii. p. 3.

|| Isbister, Quart. Jour. Geol. Soc., vol. xi. p. 511.

§ Edin. Phil. Jour., vol. iv. p. 144.

¶ Fremont's Expedition.

** Hector, Geol. Jour., vol. xvii. p. 408.

†† Pacific Railroad Report, vol. vi. p. 65.

‡‡ Jour. Soc. Arts, vol. ix. p. 98. Bauerman, Jour. Geol. Soc., vol. xvi. p. 201. Hector, Ibid., vol. xvii. p. 433.

|||| Gibbs, Pacific Railway Reports, vol. i. p. 472.

of hydrocarbons; and amongst these the lignite of Arkansas, surveyed by the late D. D. Owen,* may be especially mentioned.

Tertiary strata containing beds of coal and lignite, associated with asphalt, are widely distributed in Trinidad;† and beds of lignite and coal occur in Venezuela, on the Orinoco, in the provinces of Coro and Barcelona; and mineral pitch is extensively diffused in the provinces of Maturin, New Granada, &c.‡

A great coal-field exists in the province of St. Catharine, Brazil, extending along the coast for about 140 leagues, from Laguna almost to Monte Video, and 60 leagues in an east and west direction, from the Atlantic to St. Gabriel. Steam-coal of good quality has also been worked in seams 4 and 5 feet thick at Arroio des Katos.||

Coal of tertiary age exists at Cirnaga de Oro, on the River Tinu; on the banks of the Carare; and at Conejo, below Hondu; it also occurs in Veraguas, Chiriqui, and Costa Rica, on the Isle of Muerto, and at Tarraba. The coal of Bogotà is probably of earlier date.§

The coal of Chile¶ belongs to the tertiary formation, and is worked in the Lota and Coronel districts; it is good bituminous coal, and equal in quality to many of the best English coals.** Beds of lignite and coal are found in the islands of Chiloe, Quiriquina (Conception), and Lorenzo, off Lima.†† Coal has also been observed in the Straits of Magellan.

An extensive deposit of bituminous coal has been found in Chatham Island, one of the Galapagos.‡‡

The tertiary lignite of Macquarie Harbour, Tasmania, with its associated rich fossil flora, occurs along the north-eastern side of the estuary; it is interstratified with clay and incoherent sandstone, and contains much resin, which gives off a fragrant odour when rubbed in the palm of the hand, resembling the aroma of the Cowrie gum (resin) of New Zealand.

* Second Geol. Survey of Arkansas, 1860.

† Wall and Sawkins, Report on the Geology of Trinidad, 1860.

‡ Wall, Jour. Geol. Soc., vol. xvi. p. 467.

|| Jour. Soc. Arts, vol. ix. p. 111.

§ Bollaert, Researches in New Granada, Peru, &c.; and Geol. Quart. Journ., vol. i. p. 174.

¶ Forbes, Jour. Geol. Soc., vol. xiv. p. 294.

** Bollaert, Jour. Geograph. Soc., vol. xxv. p. 172.

†† Darwin, South America, pp. 121, 125, 284.

‡‡ Coulter, Adventures in the Pacific, p. 107; Edin. Phil. Jour., vol. xl. p. 386.

Near Auckland, New Zealand, there are beds of a similar tertiary lignite, many feet thick, also containing a peculiar resin. Similar coal has been found at Muddy Creek, at Mokau, and near New Plymouth, New Zealand.*

In Western Australia, coal of more than one kind occurs on the Irwin and Fitzgerald Rivers; but the geological age is as yet undetermined.†

In the Eastern Archipelago, fossil fuel is locally abundant. The coal of Labuan (Borneo) was noticed in 1847 by Mr. T. Bellot;‡ and in 1852 by Mr. J. Motley.|| This coal appears to be mainly composed of bituminized trunks of trees, slightly compressed, and crossing each other in all directions. The fossil wood is dicotyledonous, being like that of the *Dipteraceæ*, now living in the island. This coal contains much fossil resin.§

In Sumatra also a similar coal with resin is said to occur.

Coal-beds similar to those of Labuan exist also along the western coast of Borneo, and to the south seams of good coal occur near Bruni and in the neighbourhood. Coal has been found also at Junk-Ceylon, off the west coast of the Malay Peninsula, as well as on the south-east coast of Sumatra, and in Formosa.¶

Large beds of coal are mentioned as having been found at Chantabun, on the east coast of the Gulf of Siam.**

Lignite and coal have long been worked in Japan, as noticed by Kaempfer, Oliphant, and Elgin; and appear to be abundant.

In Northern India, tertiary coal of fair quality, as well as lignite, associated with ironstone, has been discovered near Subathoo, either in the lower Sewalik formation, or the upper nummulitic series;†† and indications of lignite have been observed both to the east and to the north-west of this locality.

The cretaceous group yields fossil fuel in Vancouver's Island, the Gulf of Georgia, and the Rocky Mountains. The best seam of coal at

* Weekes, Jour. Geol. Soc., vol. xvi. p. 197.

† Gregory, Quart. Jour. Geol. Soc., vol. xvii. p. 480.

‡ Jour. Geol. Soc., vol. iv. p. 50.

|| Jour. Indian Archipelago, vol. vi. p. 555; and Jour. Geol. Soc., vol. ix. p. 54. See also a later account in 1860, Edin. New. Phil. Jour., New Series, vol. xi. p. 166.

§ See Kew Annals of Botany for 1852.

¶ See Quart. Jour. Geol. Soc., vol. iv. (President's Address) p. lxi. and xcii.; also Jour. Indian Archipel., vol. i. pp. 80, 90, 145, 153, &c.

** Jour. Soc. Arts, vol. ix. p. 816.

†† *Times*, May 3, 1862, p. 11.

Nanaimo is 6 feet thick, and is used for gas-making at Portland, Oregon, and also in California. Similar lignite-coal occurs at Corse Bay, also on Frazer and Pitt Rivers; and even further south. Lignite beds, differing in quality, of lower cretaceous age, occur near Fort Edmonton, on the Smoking River; also on the Athabasca, M'Cleod, and Pembina Rivers.*

The Wealden of Hanover † yields good coal to some extent; in England we have this represented by jet and seams of lignite in Sussex. The coal and plant-beds of Bornholm (Baltic), and of Hoer, in Scania, are probably of oolitic age.

The mesozoic rocks yield coal in Hindostan both in Bengal (Ràjmahal, Burdwan, &c.), and in Central India (Nerbudda and Umret); the produce of the coal-fields of Raneegunge, Rajmahal, Kuhurbari, Palamow, and Sylhet in 1860 was more than ten million maunds, or about 400,000 tons.‡

Equivalent to these may be the bituminous coals of Eastern Virginia, near Richmond; and of North Carolina. In Europe the trias has a bed of lignite called letten-kohle, of but little value. In South Africa the coal of Natal may be referred to the same series. Dr. Livingstone mentions the occurrence of coal at Lofübu, two miles below Tète,|| where two seams are exposed; but it is partially affected by trap-dykes.

Carbon has always been an abundant element on the earth. For in every age, in nearly every geological period, except perhaps the very earliest, we find traces of terrestrial and other vegetation, either as impressions or fragments of stems, leaves, or fruit, imbedded in the different rocks, and variously mineralized; or as vast accumulations of vegetable matter converted into coal—the growth of luxuriant marsh-forests, either entombed on the spot, or drifted as widespread masses over the ancient sea-bed, or accumulated in estuaries and maritime lagoons. Of all the coal-bearing beds, those which are the best marked and most important belong to the early period of geologic history, and are aptly termed the carboniferous. These form, as we have shown, a group of rocks some thousands of feet thick, succeeded by many thousand feet of

* Hector, Quart. Jour. Geol. Soc., vol. xvii. p. 420.

† Dunker, Monographie norddeutsch. Wealdenbild.

‡ See the valuable Reports of the Geological Survey of India, prepared under the direction of Prof. Oldham. Hislop, Jour. Geol. Soc., vol. xi. p. 560.

|| Quart. Jour. Geol Soc., vol. xv. p. 556.

other strata. Throughout these latter strata other coal-beds appear; but these are formed of a different vegetation, showing gradual but increasing land-conditions in the successive periods of the earth's physical history.

Table of the Geological Distribution of Coal and Lignite.

British Isles.*	Age.	Foreign.
Peat and lignite.	Recent.	Peat and lignite.
Do.	Pliocene.	Do.
Lignites of Antrim, Bovey Tracey, and Corfe.	Miocene (Or Upper Eocene).	Lignite and coal of the Brown-coal deposits of France, Germany, and other parts of Europe, and Western Asia.
Lignite of Woolwich, Lewisham, &c.	Eocene.	Lignites of the Paris Basin. Coal and lignites in Tasmania, New Zealand, Valparaiso, North America, Eastern Archipelago, &c.
	Cretaceous.	Vancouver Island.
Lignite and jet, Sussex.	Wealden.	Coal at Buckeburg, Minden, &c., Hanover.
Kimmeridge shale, Coal of Skye, Coal of Brora, Moorland coal of Yorkshire, Jet of Whitby, &c.	Oolite and Lias.	Coal of Bornholm. Coal of Cutch, Burdwan, Rajmahal, Damuda, Nerbudda, and Umret. Coal of Eastern Virginia and North Carolina.
	Trias.	Lettenkohle of Germany. Coal of Natal (?).
	Permian.	Brandschiefer of Saxony; Lignite and jet of Spain and Russia.
Coal, Anthracite, Cannel, Culm, &c., of the coal-measures and mountain limestone.	Carboniferous.	Coal-fields of Europe, China, Australia, Tasmania, North America, and Brazil (?).
	Devonian.	Anthracite, New Brunswick.
Anthracitic beds in Ireland, Wales and South Scotland. Graphite.	Silurian and Cambrian.	Bituminous schist, Russia. Anthracite in Sweden and Germany. Graphite.

* Some of the coal-bearing strata, such as those of the Trias, Permian, and Devonian Series, are in the British Islands represented by plant-bearing beds of greater or less extent and richness.

SEC. II.—WHAT COAL CONSISTS OF.—Carbon, either alone or in combination, is widely distributed in nature, forming an essential part of most animal and vegetable bodies, entering into the composition of many useful minerals, and constituting a large portion of many rocks. In its pure and crystallized state, it forms the well-known gem the diamond. Graphite (plumbago or black-lead) is also pure carbon, mixed with a small quantity of iron. Carbon forms also the basis of charcoal and coke, as well as the anthracites and semianthracitic coals, in which its proportion varies from 84 to 94 per cent. Combined with oxygen (one of the elements of water), carbon forms carbonic oxide and carbonic acid, the choke-damp of the miner. Combined with hydrogen (another element of water), it constitutes olefiant gas and carburetted hydrogen (which, mixed with atmospheric air, is the explosive fire-damp of coal-mines), as also those numerous hydro-carbons so well known to chemists, as benzole, naphtha, naphthalin, paraffin, &c., and elaterite (or elastic bitumen), hatchettine (or mineral tallow), and ozokerite, found in the coal-strata, and scheererite, konlite, and hartite, from the brown-coal. Combined with hydrogen and oxygen, carbon forms middletonite and schleretinite of the coal-measures, and hartine, walchowite, and retinite of the brown-coal; also copaline and amber.

Mineral or rock-oil is extensively found in North America, especially in the Alleghany bituminous coal-field; the oil-region comprises parts of Ohio, Pennsylvania, Kentucky, Virginia, Tennessee, Arkansas, and Texas, as well as of Canada, where the oil-wells lately discovered appear to rival, if not surpass in volume and persistency of flow, those of Pennsylvania. The oil is stated to be derived not only from the carboniferous, but also from the devonian and silurian rocks. The Burmese naphtha, or Rangoon tar, is obtained from wells near the Irawaddy, in the Burman empire. Mineral oils are found in many islands of the Indian Archipelago, as in Java and Sumatra, where they rise from fissures in strata overlying volcanic rocks.*

Bituminous sands and clays are found in many parts of Central and South America, and the prairie-gas-stone of Illinois is a grey limestone with the pores containing bitumen.† In this country some of the coal-rocks of Shropshire contain mineral tar.

* Dr. Bleekrode, On Mineral Oils of Java, in the Repertoire de Chimie appliquée.

† Gesner, On Coal, Petreoleum, &c., 1861; also Geol. Jour., vol. xviii. p. 3.

Carbon, hydrogen, oxygen, and nitrogen are the constituent elements of plants, peat, lignite, and coal, varying in proportion in the latter according to the changes the vegetable matter has undergone, or the difference in the composition of the original plants from which the coal was elaborated. Thus—

	Carbon.	Hydrogen.	Oxygen, Nitrogen, &c.	Ash.	Observers.
Woody fibre	52·65	5·25	42·10	..	Schödler.
Larch wood	50·11	6·31	43·58	..	Do.
Charcoal	87·68	2·83	6·43	3·06	Muspratt.
Peat, Shannon	60·01	5·87	34·10	0·95	Sullivan.
Lignite, Cologne	63·42	4·98	27·11	..	Regnault.
Coal, Newcastle	82·24	5·42	9·40	2·94	
Cannel	79·23	6·08	9·85	4·84	Playfair.
Boghead	69·93	8·85	5·68	21·22	Penny.
Albertite	85·40	9·20	5·28	0·12	Jackson.
Merthyr coal	90·27	4·12	4·36	1·25	Playfair.
Duffryn coal	88·26	4·66	3·22	3·26	Do.
Anthracite	91·44	3·84	3·58	1·37	Wrightson.
Graphite	92	Iron 8.		..	Vauquelin.

Having now described where coal occurs geographically and geologically, and also the elementary materials of which it is composed, a few remarks may be useful on the manner in which it occurs. Confining ourselves to the coal-measures proper, they are found to consist of alternations of sandstones, shales, and coal, with occasional limestone bands. The coal itself bears a very inconsiderable proportion to the other materials—some coal-fields, for instance, being thousands of feet in thickness, with barely a hundred feet of good coal. The seams of coal vary in number in the different coal-fields (in Belgium there are nearly a hundred); they vary very much in thickness (from 1 inch to 6 or 7 feet), occasionally reaching 30 feet (South Staffordshire). In some places in France we meet with seams even 40 feet thick (Saône-et-Loire); and seams of similar thickness occur in Pennsylvania.

A coal-seam presents this kind of section, descending:—

1. Indurated clay or shale (sometimes called bind, clunch, or grey metal), frequently containing fragments of plants *Calamites*, *Sigillaria*, ferns, &c., or occasionally bivalve shells (*Anthracosia*), and forming the "roof;" of variable thickness.

2. Black bituminous shale, or laminated clay, with thin layers of coal, containing plants, and sometimes remains of fishes; 4 to 6 inches or 1 foot.

3. Coal, generally consisting of distinct layers of bituminous coal, separated by thin layers of charcoal fragments parallel to the plane of bedding.

4. "Floor," composed generally of a dark or grey tenacious clay (called under-clay, seat-earth, fire-clay, and spavin), and containing dispersed through it numerous remains of *Stigmaria* and its appendages. Thickness from about 1 inch upwards.

In some districts, as in Yorkshire, the roof of the coal is sandstone (termed rock-roof); and sometimes the floor of the coal consists of an indurated sandstone, instead of clay, containing *Stigmaria*. This is known as "ganister" or "calliard" in Lancashire and Yorkshire, where it belongs to beds in the lower coal-series.

In certain districts the under-clay is wanting—as in some coal-seams of the millstone-grit and mountain-limestone. The character of the coal sometimes varies in the same seam; thus, the low main in the Newcastle district is good house-coal in one part, a better gas-coal at another, and a steam-coal at a further distance. Prof. Rogers has pointed out the increasing proportion of volatile matter in the coal of the Appalachian basins, in proceeding from the south-east to the north-west, a reverse of that which takes place in South Wales, where the bituminous coal occurs in the eastern, the semi-bituminous in the central, and the anthracite in the western part of the coal-field.

I need not now enlarge on the subject of the origin of coal from vegetable matter, and will merely enumerate Ferns, Sigillariæ, Lepidodendra, Calamites, Asterophyllites, Sphenophylla, &c., as being essentially the plants from which the different beds of coal have been elaborated, whether from the growth of this vegetation on the spot, or from the accumulation of drifted trees and herbage.

In conclusion, we may remark that there are different kinds of coal which have resulted from the nature of the vegetation of which the several varieties have been composed, and partly from the chemical changes to which they have been severally subjected.

There are two principal kinds, namely, the bituminous and the non-bituminous—the former including the semi-bituminous, cherry, splint, and cannel coals. The cannel or parrot coal affords the largest amount of gas, and is used for the manufacture of hydro-carbons, naphtha, paraffin, &c. The second kind include the anthracite and semi-anthracitic varieties, which burn with little flame, and yield but little volatile matter.

These coals are variously distributed—bituminous coal and its varieties being found in all the coal-fields. Scotland is rich in cannel or parrot coal; and cannel is worked in Lancashire, Yorkshire, North Wales, and the Newcastle districts. Steam-coals are found in South Yorkshire, Northumberland, and South Wales; and anthracite is largely developed in the coal-field of South Wales, and is worked in Ireland.

Ordinary Meeting, Monday, December 2nd, 1861.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair.

The following were elected members of the Association:—Miss Hastings; Rev. E. Wyatt-Edgell; G. L. Figge, Esq.; H. Elliot Fox, Esq.; H. Monkton, Esq.; T. J. Newstead, Esq.; Rev. O. F. Owen.

The following donation was announced:—

On Peat and Peat-Charcoal, by W. H. Buckland, Esq. From the Author.

The following papers were read:—

1.—"On Two Beds of Re-deposited Crag Shells in the Vicinity of Yarmouth, Norfolk." By C. B. Rose, Esq., F.G.S.

To the westward, and immediately adjoining Yarmouth, lies Breydon Broad (a lake), the common embouchure of three rivers, viz., the Bure, Yare, and Waveney; the united waters, taking their course to the sea, form the harbour of the town.

From the south-town side of the harbour starts the East Suffolk Railroad, and about one mile from the station, in a cutting of the line, two thin beds of re-deposited Crag shells are exposed. The section at the spot, examined by me, is from ten to twelve feet in depth. At five feet from the surface is a deposit of the shells, chiefly in fragments, in a light-coloured sand; and four feet below the above occurs a second deposit of shells, of the same character as those in the upper beds; each bed is but from three to six inches in thickness; a gravelly sand, composed of small angular flints and pebbles, lies above, between, and beneath the two beds of shells, as far as the strata are opened by the cutting—my lower or crag-drift.* The strata of shells rise from the valley in which Breydon lies—towards the south, at an angle of between 20° and 30°. Beyond the third telegraph-post, from the footpath to Mr. Bell's farm, and twenty paces to the south of it, the beds of shells terminate, marking, probably, the former southern border of the bay in which the re-deposit took place. The elevation of the beds of shells above low water at Breydon is respectively twenty-five and twenty-nine feet. At the upper part of this once estuary, near to Norwich, the *original* deposit of the crag is met with at the height of forty feet above the level of the valley. The rationale of this re-deposit of shells appears to me to be, that during the deposit of the lower drift, as this estuary was slowly emerging from the ocean, portions of the original crag, lying in a north-western direction, were disrupted by the agency of water, and borne to the locality now occupied by them and their fragments.

There is a very interesting feature connected with this re-deposition of shells—the formation of dendrites upon them and the pebbles associated with them. As nothing of the kind is seen upon the original Crag shells of Suffolk and Norfolk, it is fair to conclude that these dendritic appearances have originated and been perfected subsequently to the re-deposit of the shells. Similar dendritic pictures are abundantly met with on the faces of the flints in the gravel-beds about Norwich—productions of the drift; and I have a specimen on a Pecten in a boulder from the Boulder-clay of West Norfolk; still it is evident that these arborizations are not formed on exposed surfaces only, for I have noticed them within fresh fractured flint; and, when so seen, they exhibit a bright, metallic lustre, not the dead black of those on *old* exposed surfaces; in the first instance, showing the metal (manganese) in its native metallic state; in the latter, the black oxide, time, and exposure to oxygen, having effected the change. These appearances are analagous to those on the so-called landscape-marble.† The shells from the above beds, most of which I have

* The Geologist Magazine, vol. 3, page 137. "On the Divisions of the Drift in Norfolk and Suffolk."

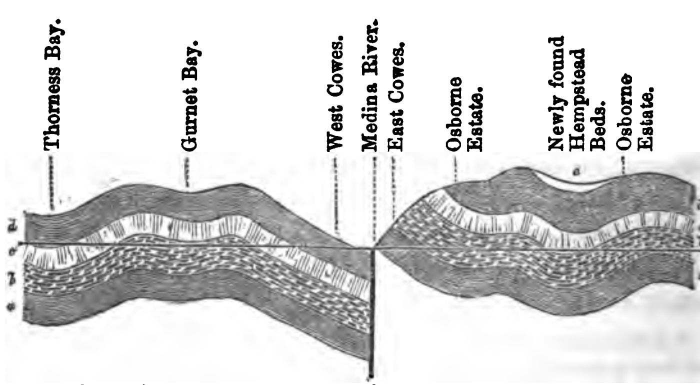
† The lignograph given by the late Dr. Mantell, in his "Medals of Creation:" vol. 1, page 104, 1st edition, as the representation of a Confervite, is, in reality, but a dendritic arrangement of particles of Silicate of Iron, or of Oxide of Manganese. It was first figured by the late Mr. Woodward, in his "Geology of Norfolk;" from the original specimen in my collection.

identified, are Cyprina Islandica in fragments; Tellina, two species; Mytilus, Leda (?), Mactra, Pecten (two or three species), Astarte sulcata (?), and A. compressa (?), Mya, Cardium, Pectunculus, Turritella communis, Purpura (a fragment), Buccinum striatum (?), Natica (?).

Among the sand, I met with some Foraminifera, very minute pieces of coniferous wood, probably silicified; and little fragments of *fibrous* carbonate of lime; small masses of this mineral are met with in a gravel-pit seven miles to the north-west of Yarmouth.

2.—"On a newly-discovered Outlier of the Hempstead Strata on the Osborne Estate, Isle of Wight." By Dr. E. P. Wilkins, F.G.S.

It will be interesting to geologists to know that another outlier of the Hempstead Strata has been discovered in the Isle of Wight. The locality is one where we might scarcely have expected to meet with these beds, from the peculiar local condition of the Upper Tertiaries, as laid down in geological maps of the island. In the line of the River Medina, running north and south, a fault occurs which breaks the continuity of the strata. On the west side of the Medina the Bembridge series constitute the superficies, while on the east side of the river the lower beds are thrown up and crop out. At the mouth of Cowes Harbour, on the west, the Bembridge Limestones are found at high-water mark; above these, to the basement-bed of the Hempsteads, are strata measuring 110 feet.



a. Headon series.
b. Osborne series.
c. Bembridge limestone.
d. Bembridge marls.
e. Hempstead series.

DIAGRAM-SECTION, SHOWING THE OUTLINE OF HAMPSTEAD STRATA AT OSBORNE.

On the east side of the river the Osborne and Headon beds crop out above high-water mark—the thickness of which strata is 260 feet. Under these arrangements Hempstead beds might more fairly have been expected to be met with on the heights above the west shore of the Medina—but it is not so. On the east side of the river, Bembridge and Osborne beds, after cropping out, dip considerably to the east, and thus the lower beds of the Hempsteads have escaped the force of denudation, and are found capping the hill over the synclinal line of the dip.

Being in the habit of watching the operations of well-sinkers hereabouts, my attention was called to a well which was being sunk near the keeper's lodge on the Osborne Estate. I made a collection of fossils from the clay turned out from this well.

The fossils collected struck me as different from those of the Bembridge series, which the Geological Survey map represents as constituting the strata of the locality, yet for some time their concord with the fossils of the Lower Hempsteads did not occur to me. This collection of fossils was put into a tray for future observation, and, on again examining them, their agreement with some of the fossils of the Hempsteads attracted my attention. The first observation made by Mr. Keeping when I showed them to him was, " They are fossils of the Lower Hempsteads." This opinion I consider decisive, because Mr. Keeping is thoroughly acquainted with the Hempstead beds, indeed more so than any other person, having been for many years watching and collecting from these strata. The productions of this well have been carefully and comparatively examined with the fossils of the Lower Hempstead beds, and they are found to accord with the fauna of beds midway between the *White Band* and the *Black Band*, described by Professor Forbes and Mr. Bristow as " dark blue shaly clay," yielding Cyrena semistriata, Modiola, Rissoa Chastellii major, Cyprides, &c.* The bed at Osborne consisted of dark blue shaly clay, and yielded to me Cyrena semistriata, Cyrena obovata, Cerithium plicatum, Modiola Nystiana, Corbula Vectensis, Neritina concava, Rissoa Chastellii, Melania, &c.

3.—" On the Exchange of Fossils among the Members." By A. Bott, Esq., A.A.

Mr. Bott stated, that having found the difficulty of getting members to

* Mem. Geol. Surv., 1856; Tert. Isle of Wight, p. 43.

exchange specimens, and having received letters from a country member, complaining of the same, he thought it might not be out of place, at the beginning of the session, to say a few words on this subject. The Association would remember it was part of their original prospectus, that the object of the Association was, amongst other things, "to facilitate the exchange of fossils among the members;" and again, it was proposed even "to form a committee to communicate with members as to the exchange of fossils, and the supply of specimens for the museum:" so that the Association gave every facility in its power for carrying out this part of its programme.

He believed that most members who were collectors were possessed of duplicate specimens of many of these fossils; and yet, though they had the power, though they had the services of an Association, one of the objects of which is to facilitate the exchange of specimens, and though they had the fossils at their command, hardly any of them in fact made such exchanges. He believed the only reason was, that different people put such a very different value on the same specimens, each imagining his fossils to be more valuable than those of another person.

He would urge upon members not to be too particular as to the money value of the fossils they received in exchange for what they sent, and reminded them, at all events, they could obtain fossils which they did not possess before, which was the great object of exchange. He himself had acted with advantage on the plan of trusting entirely to his correspondent; having effected a satisfactory exchange of fossils with another member who, having heard through the Association that he wished to exchange, wrote to ask for some fossils from his (the author's) district, promising to send fossils from his own district in return. This was done, and the result was satisfactory to both parties.

He would, therefore, urge upon those members who had duplicates to share the advantage of exchange.

4.—Professor Tennant exhibited some specimens of gold recently forwarded from Nova Scotia to this country. He read extracts from a report which was made by Mr. Howe to Lord Mulgrave, the Governor of the colony, in September last, from which it appeared that the gold discoveries made in the colony in 1860 had been found to be unimportant, the gold occurring in quantities so small as not to afford a satisfactory return for the labour of seeking for it. The excitement had accordingly subsided. Last March, however, a man accidentally discovered a piece of gold among the pebbles in a brook. This led to further investigation, and it is now generally believed that gold in abundance exists in the colony within an easy distance of means of transport; and Mr. Howe considers that the Government will be warranted in assuming that at the localities where the chief working has been hitherto carried on, viz., Tangier, Lunenburg, Lawrencetown, and Lake Thomas, gold-mining will be permanently established as a new branch of industry, tempting to the capitalist and attractive to the immigrant. The gold is found in quartz-veins, and in the sand on the sea-shore. Specimens of gold in the matrix and some of the gold grains found in the sand were exhibited, as also two ingots of pure gold, cast from that discovered in the above-mentioned workings.

5.—On a New Method of Preparing Peat for the purposes of Fuel and Gas-making, by W. T. Rickard, Esq., F.C.S.

In bringing before the Association a model of a machine for utilizing Peat, and rendering that substance available as fuel, in quantities and at prices commensurate with the public requirements, I may briefly state that during the last twenty years various plans have been proposed for this object, and much capital expended, without having attained the desired results. The failures of these attempts may be attributed, generally, to *their having been conducted on the erroneous principle of pressure; the employment of expensive and complicated machinery; operating on the upper surface and less decomposed portions of the Peat deposits;* and, finally, *neglecting to separate the coarse fibrous portions*, by which the manufactured article was so light, and retained so much moisture, that it was comparatively valueless as fuel.

All these objections are overcome by the very simple and inexpensive method of treatment now proposed, which is as follows:—As soon as the moist Peat is taken from its deposit (the lower portion, containing least fibrous matter being preferred) it is thrown into the machine, which consists of a funnel-shaped strainer of stout sheet iron (terminating in a tube), and having a conical cast-iron screw fitting the interior of the perforated funnel, which screw, revolving at the rate of 70 per minute, rapidly forces the decomposed portions of the Peat through the perforated funnel, while the larger fibres and other extraneous matter is got rid of through the tube at the bottom, and may serve as fuel for the steam-boiler. The strained Peat is then moulded into any form that may be desired (a common brick-machine answers the purpose admirably), and submitted for two or three days to a temperature of about 98° Fahr., by which time it will have become nearly as hard as oak, retaining very little moisture (one sample I analyzed gave but 2 per cent., which is not more than ordinary coal), and having a high specific gravity—from 1·5 to 2·0; ordinary dried Peat being ·350 to ·800, and rarely exceeding 1·00. It is now ready for use or sale; and, as no compression has been applied, it has received the distinctive name of *Condensed* Peat.

It is stated by the inventors of the machine (Messrs. Buckland and Brunton, 5, Barge-yard, Bucklersbury) that the cost of the operation is less than 3s. 6d. per ton on the dried Peat produced. Should this be confirmed by operations on the large scale, and which are now in progress in the vicinity of Belfast and of Sligo, it is obvious that the Peat deposits of Great Britain, *which are said to exceed six million acres*, must shortly become a source of national wealth, second only to our coal.

The cheapness, simplicity, and durable nature of the machine is a very favourable feature in the affair. The inventors inform me that a strainer 2 feet in diameter (costing about £50) will discharge 80 tons of crude Peat in twelve hours. As this crude Peat contains from 50 to 75 per cent. of moisture, about 25 tons of dried will be about the daily production.

I have tried it in my assay-furnace, and obtained results equal to those from coal or coke; such results I have never yet obtained from Peat prepared in any other manner.

From analyses and experiments which have been made at different times by Dr. Letheby, Mr. Versmann, myself, and other chemists, besides the reports of several eminent ironmasters and engineers, it is clear that Peat offers many advantages for the manufacture of gas and iron, arising chiefly from its comparative freedom from sulphur and phosphorus, which substances are so notoriously pernicious in both of these important operations.

To convert this dried Peat into Peat-charcoal (the great value of which is now so generally known), from 2 to 3 tons are required to produce 1 ton of charcoal; and 2 to 3 cwt. of Peat-grease, containing Paraffin, is obtained from the products of distillation.

It may also be used extensively as a means of utilizing small coal. It is found that an excellent fuel for steam-purposes is produced by mixing, while the Peat is in a moist condition, 50 per cent. of small coal, before submitting it to the drying operation. This article is free from the objection to ordinary "patent fuel," wherein pitch is usually the cementing medium, and which is apt to run together in warm climates.

The specimens before you exhibit—1st, the Crude Peat; 2nd, Moist Peat after straining; 3rd, Dried Peat from Ireland and various parts of England, moulded into different forms; and 4th, two specimens of Charcoal from ordinary air-dried and Condensed Peat, the heavy, compact nature of the latter contrasting favourably with the light and friable condition of the former.

A model of the machine was exhibited.

A discussion followed, in which the President, Mr. White, Mr. Lawson, Mr. E. Jones, Professor Tennant, Mr. Cumming, Mr. Bott, and other members took part.

The President read to the meeting the list of the names of those gentlemen whom the committee had determined to recommend for election as officers of the Association for 1862.

Mr. Collingwood and Mr. Evans were appointed Auditors to examine the accounts of the Association for 1861.

Annual General Meeting, Monday, January 6th, 1862.

The Rev. Thomas Wiltshire, M.A., F.G.S., President, in the Chair,

The Annual Report of the Committee was read as follows:—

REPORT.

The Committee have great pleasure in again congratulating the members upon the continued success of the Geologists' Association.

The great and increasing interest which the Association has excited is evinced by the fact that no less than fifty-seven new members have been proposed and elected during the past year, as against thirty-one in 1860.

The Association has to regret the loss by death of Professor Henslow, one of its earliest life-members, who always expressed the liveliest interest in its welfare.

The finances of the Association are in an exceedingly satisfactory condition; and, notwithstanding increased expenditure, the balance in th hands of the Treasurer is £54 1s. 11½d., being an increase of £21 8s. 8½d., over that which he held at the beginning of the last year.

The plan of conducting occasional excursions to places of geological interest, which was organized in 1860, has proved a complete success.

Excursions have during the past year been made to Reigate, Oxford, and the Isle of Sheppey; and the large number of persons who have availed themselves of the opportunities thus afforded of acquiring geological knowledge bears testimony to the great estimation in which they are held.

It was not found practicable to make more than three excursions in 1861, but during the next summer it is proposed to increase the number to four, and to visit Tunbridge or Hastings, Harwich, Cambridge, and Lewes.

The Committee have laid out a sum of £8 in the purchase of several standard geological works. This expenditure appears to have been judicious, inasmuch as there is a great demand among the members for the works so purchased, and nearly all of them are in constant circulation.

The Committee finding from the Auditors' report that there is a very satisfactory balance in the hands of the Treasurer, and remembering that by the investment of Mr. Brown's legacy they have a fund more than sufficient to cover every possible liability, propose to lay out a further sum of not less than £5 in the purchase of books, believing that in no way could the funds of the Association be applied in a manner more calculated to further the object contemplated by its founders.

They have to acknowledge with thanks several donations both to the library and museum, which have been made by members and others taking an interest in the prosperity of the Association.

The fossils in the possession of the Society have now been nearly all arranged, and, it is thought, will be found to form a good nucleus round which a useful collection may eventually be gathered.

The following papers have been read during the year:—

"On the Geology of the Isle of Sheppey." By the Rev. R. Bingham, M.A.

"On Discoveries in the Lower London Tertiaries at Dulwich and Peckham, during the excavations for the Effra Branch of the Great South High Level Sewer." By Charles Rickman, Esq.

"On Casts of the Calcareous Plates, or *Opercula*, of *Ammonites*, in

Flint Pebbles, from the Gravel at Whetstone." By N. T. Wetherell, Esq., M.R.C.S.

"On Oviform Bodies from the London Clay, Chalk, and Greensand Formations." By N. T. Wetherell, Esq., M.R.C.S.

"On a Plant Bed cut into by the Severn Valley Branch of the West Midland Railway." By G. E. Roberts, Esq.

"Observations on the Geology and Superficial Accumulations of the North End of the Penine Chain and Adjacent Depression." By J. Curry, Esq.

"On the Opercula of Recent Gasteropodous Mollusca." By J. Pickering, Esq., Vice-President.

"On the Pitharella Rickmani." By J. Pickering, Esq., Vice-President.

"On the Geology of the Isle of Portland." By W. Gray, Esq.

"On some Anomalous Fossils from the Upper Greensand of Cambridge." By Harry Seeley, Esq.

"On the Geology to be learnt from the Paving Stones of London." By Professor Tennant.

"On the late Excursion made by the Association to Reigate." By J. Cumming, Esq.

"Notes on the Fossils of the Gault, from the Alice Holt Forest, near Alton." By W. Curtis, Esq.

"Hints for Summer Rambles." By Geo. E. Roberts, Esq.

"On the late Excursion made by the Association to Oxford." By P. Badcock, Esq.

"On the Efflorescence which succeeds the Action of Heat on certain Sandstones of Yorkshire." By C. Tomlinson, Esq.

"On Science applied to Practical Agriculture." By L. M. Woodward, Esq.

"On a Deposit of recent Shells and Bones in the Cliff of Monk's Bay, Isle of Wight." By Mark Norman, Esq.

"On Worm-burrowings in some Clays at Bendigo, Australia." By R. J. L. Guppy, Esq.

"On Geological and Mineralogical Hammers." By Samuel Highley, Esq., F.G.S., F.C.S., &c.

"On the Taranaki Iron-sand." By Samuel Highley, Esq.

"On the late Excursion made by the Association to the Isle of Sheppey." By Samuel Highley, Esq.

"On Coal, its Geological and Geographical Position." By Professor Morris, V.P.G.S.

"On two Beds of re-deposited Crag Shells in the vicinity of Norfolk." By C. B. Rose, Esq., F.G.S.

"On a newly-discovered Outlier of the Hempstead Strata, on the Osborne Estate, Isle of Wight." By Dr. E. P. Wilkins, F.G.S.

"On the Exchange of Fossils among the Members." By A. Bott, Esq., A.A.

"On Gold Discoveries in Nova Scotia." By Professor Tennant, F.G.S.

"On a New Method of Preparing Peat for the Purposes of Fuel and Gas-making." By W. J. Rickard, Esq., F.C.S.

Nearly all the above Papers have been printed at length, and the Committee are happy in stating that they have been able materially to increase the amount of printed matter circulated among the members, without unduly trenching on the funds of the Association.

In conclusion, the Committee beg to remind members that a great deal of support may be given by them, if they will use their influence in interesting others in the Association, and obtaining new members; and thus enable the Committee, at the end of the year, to congratulate the Association on a still larger accession to its numbers.

It was resolved unanimously that the Report be adopted.

The following were then elected Officers of the Association for the year 1862:—

PRESIDENT.

Professor Tennant, F.G.S.

VICE-PRESIDENTS.

J. Pickering, Esq.	Rev. T. Wiltshire, M.A., F.G.S.
T. Sopwith, Esq., F.R.S.	C. Woodward, Esq., F.R.S.

TREASURER.

W. Hislop, Esq., F.R.A.S.

GENERAL COMMITTEE.

A. Bott, Esq., A.A.	S. Highley, Esq., F.G.S.
T. Brain, Esq.	T. Lovick, Esq.
E. Cresy, Esq.	B. Marriott, Esq.
J. Cumming, Esq.	W. T. Rickard, Esq., F.C.S.
C. Evans, Esq.	G. E. Roberts, Esq.
J. F. Collingwood, Esq., F.G.S.	C. Tomlinson, Esq.

HONORARY SECRETARY.

W. N. Lawson, Esq., M.A.

HONORARY LIBRARIAN.

J. Cumming, Esq.

The following Balance-sheet was then submitted, signed by the Auditors :—

GEOLOGISTS' ASSOCIATION.

Annual Statement of Receipts and Disbursements for the Year 1861.

	£	s.	d.		£	s.	d.
Balance from 1860	32	13	3	Printing	37	0	6
Annual Subscriptions	95	9	4½	Petty Cash, Advertisements, Postage, Stationery, &c.	17	1	3
Life Subscriptions	22	1	0	Attendance, Firing, &c. ..	8	2	1
Interest of Stock	1	16	2	Books	8	8	0
				Rent	25	0	0
				Editing, Engraving, &c...	2	6	0
					97	17	10
				Balance in Treasurer's hands	54	1	11½
	£151	19	9½		£151	19	9½

We have this day examined the accounts of the Treasurer of this Association, and find a balance of £54 1s. 11½d. in his hands.

(Signed) J. Fred. Collingwood.
C. Evans.

Jan. 3rd, 1862.

On the motion of Mr. Tomlinson, seconded by Mr. Collingwood, a vote of thanks to the Rev. Thos. Wiltshire, for his conduct during the two years he had been President of the Association, was carried unanimously.

The Rev. Mr. Wiltshire, in acknowledging the compliment, said it was highly gratifying to him to find that his efforts in the cause of the Association were considered worthy of such hearty recognition. He had been one of its earliest members, and had ever done his utmost to promote its welfare. It could not be disguised that at the beginning there had been a difference of opinion as to what the Association ought to be. Too many wished to make it the rival of the Geological Society. He had endeavoured, during the rather more than two years he had had the honour of presiding, to make it occupy its proper place: to make it not the rival of the Geological Society, but a Society of learners—of those who did not aspire to be classed with the masters of the science, but who were nevertheless desirous of obtaining such a knowledge of Geology as should be at once interesting and useful to them. The feeling of the Association towards him had always been so kind that he was sure, had he desired it, he would have been re-elected President; but he thought he should not be doing his duty in retaining that position, and preventing others more able and better qualified coming forward. He had, therefore, at the previous council-meeting, with much pleasure, proposed Professor Tennant as his successor, who, he knew, took the greatest interest in the progress and prosperity of the Association.

On the motion of Dr. Richardson, a vote of thanks to those officers of the Association for the year 1861, who had been re-elected, was carried unanimously.

On the motion of Mr. Cresy, seconded by the Rev. Thomas Wiltshire, a vote of thanks to those officers of the Association for the year 1861, who had retired, was carried unanimously.

Ordinary meeting, Monday, Jan. 6, 1862.

Professor Tennant, F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:— Rev J. J. C. Valpy, H. J. Lister, Esq., J. S. Phené, Esq., C. Wallace, Esq.

The following donations were announced:—

A Collection of Mountain-limestone Fossils. By J. Rofe, Esq.

The Geologist Magazine, No. 49. By the Editor.

A Parliamentary Return on Limestones for Building. By Professor Tennant.

The following papers were read:—

1.—"On Lime and Limestones." By Professor Tennant, F.G.S., &c., President.

All limestones have for their basis carbonate of lime—a substance which occurs most abundantly in nature, both crystallized and uncrystallized. In the former state it is met with in the crevices of rocks and in the hollows of fossils, &c., and in the latter condition intermingled through the strata.

Carbonate of lime (calcite), when crystallized, is subject to great modification of form. Count Bournon, in the year 1808, figured 650 varieties of its crystals, to which Mr. Levy, in 1837, added 120 that had been previously undescribed. Numerous as are these variations, more than one-half of the whole number of 770 can be obtained from the British Isles, from the mountainous districts of the north in Derbyshire, Cumberland, and Durham, and of the west in Cornwall, Devonshire, and Somersetshire.

The crystals generally may be grouped in three great divisions.

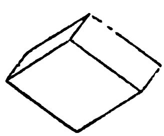


Fig. 1.

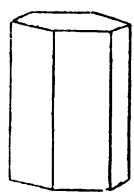


Fig. 2.

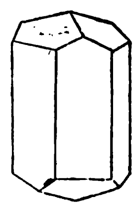


Fig. 3.

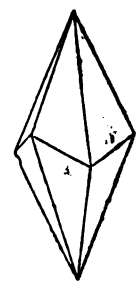


Fig. 4.

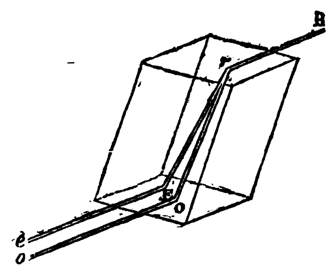
The first is that of the rhomboid (Fig. 1); the second that of the hexagonal prism (Fig. 2), common in the mining districts of the Hartz mountains, and another modification (Fig. 3) common in Cumberland about Alston Moor; the third (Fig. 4) is that of the double six-sided pyramid, called by the miners of Matlock "Dog's-tooth Spar."

If one of these crystals, even though it be most complicated in external structure, be either roughly broken with a hammer, or pounded to the finest dust in a mortar, the result is always the same—a certain shape, bounded by certain angles. See Fig. 1. As an illustration I will break this specimen; the fragments will all prove to be rhomboids.

This law, like many others now acknowledged, was discovered through an accident. The Abbé Haüy, on inadvertently letting a fine group of Derbyshire crystals fall to the ground, noticed that the fragments preserved a beautiful symmetry through every part. Struck by this fact, he was led to examine other substances, and found that they also resolved themselves into definite forms; and from them deduced the great law I am now about to describe. This accident, if we may so call it, was therefore the cause of crystallography being elevated to the rank of an exact science.

This property possessed by crystals, which causes them to break more easily in one direction than in another, is called cleavage, and serves in some cases to distinguish one mineral from another. For example, the cleavage of Iceland spar is 105° 5′ by 74° 55′. Dr. Wollaston, who measured a number of specimens which he took to be Iceland spar, found among them one that measured 106° 15′ by 73° 45′. He concluded that this last must, from the diversity of inclination, be a different mineral; and so it proved. He gave the specimens to a chemist, who analysed them, and found that the one which differed in the measurements of the angles was a magnesian carbonate of lime, and not a pure carbonate: it is called *pearl-spar*. There is another variety called *brown-spar*, which is a carbonate of iron, and which measures 107° by 73°.

Carbonate of lime also introduces to our notice another remarkable property connected with certain crystals, that of double refraction, or polarization, in which a single incident ray of light, R *r*, after entering the substance of the crystal, is split into two rays, *r* E and *r* O. The ray *r* O



still continues in the same plane as the incident ray R *r*, and is also refracted according to the usual law of refraction which belongs to water, glass, and all other substances, which simply refract without doubling or splitting the refracted ray. The other ray, *r* E, is refracted according to a very different law from that of ordinary refraction. Both rays emerge in the directions E *e* and O *o*, and have acquired the same properties which ordinary light acquires when reflected by certain non-metallic polished surfaces, or when transmitted through parallel plates of any single-refracting media, at certain angles.

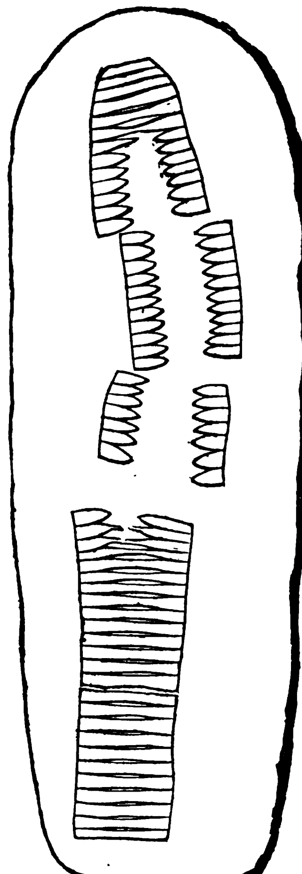
This singular change is best shown in calcareous or *Iceland* spar, as it is termed, which, when placed over a wafer, a pin, or other object, doubles the image. It takes its name of Iceland spar from the country whence the best specimens are brought, but equally good examples may be obtained from Mexico, Australia, and Canada—a fact worthy of attention.

Carbonate of lime occurs in another form in stalactites and stalagmites. Stalactites may be seen under many of the railway-bridges about London; the rain-water passing through the mortar displaces a portion of the lime, and pendent icicles, as it were, are formed. But it is in limestone districts that they are especially common. When they grow upwards from the bottom of caverns, instead of growing downwards from the ceiling, they are termed stalagmites. Running water often deposits lime, and then it is the same as the "fur" of the tea-kettle, and the "stone" of so-called petrifying springs; if such water passes through pipes it occasionally causes obstructions. On the table is exhibited the effects of its deposition on a wooden pipe, where all the markings and grain of the wood are beautifully preserved, as though they had been obtained by a cast of plaster of Paris. The carbonate of lime had been so quickly deposited that in the course of three years the supply of water had been reduced one-third. In the limestone districts of this country, such as Matlock, at the so-called petrifying wells, are to be seen birds' nests, baskets, and many other things, immersed in running water, and looking as though they had been transformed into stone; but in reality they are merely coated with calcareous matter. The material termed calcareous tufa is another substance derived from the same source, and has formed beds of great extent.

The next division of my subject is the limestones themselves. If we take them as a group, we find that they are deposited in every great formation. They occur in the lower silurian rocks in great quantities, mixed up with alumina. Rising upwards we find in the carboniferous system, in the oolites, and in the cretaceous strata, the same results; in each and all carbonate of lime is abundant.

Hardly a street can be traversed or a room entered without finding signs of organic remains formed of this substance. In the chimney-piece before you is a collection of fossils, where every white mark gives a section of a curve, that curve affording some indication of a fossil. This specimen that I hold in my hand is a piece of common limestone that I picked up at Bristol, containing a fossil; it is a stem of an encrinite, which has become disjointed and broken at one point, and forced out of the line of continuity—thus offering three different sections.

The limestone containing the encrinite is so common that it is used as a road-material in the neighbourhood of Bristol. On searching many of the old walls in a limestone district, you will often find that the weathered

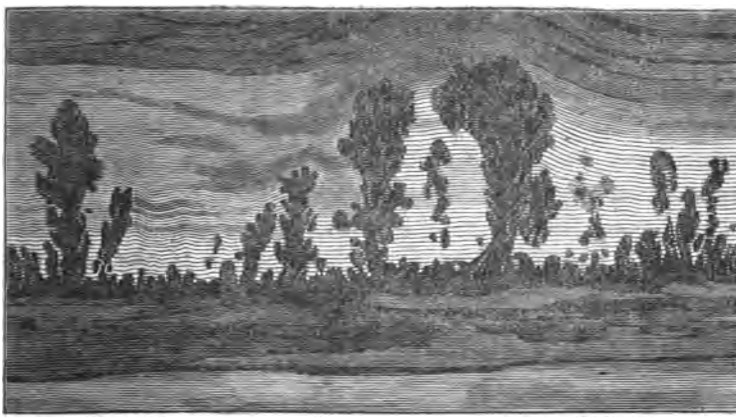


SECTION OF A PORTION OF THE STEM OF AN ENCRINITE, FROM THE MOUNTAIN-LIMESTONE.

surface will exhibit different portions of such columns of joints or ossicles; these become disjointed, and they are often threaded and worn as beads—"St. Cuthbert's Beads," as they are termed.

Whenever limestone comes in contact with the igneous rocks, it puts on a crystalline appearance, as in the case of the delicate statuary marble, which is nothing more than limestone affected by heat. Beautiful examples of this change are to be seen in the north of Ireland, near the Giant's Causeway, where the chalk is converted into a crystalline substance, almost as white as Italian marble.

Another form of limestone is the very interesting one that is known in the neighbourhood of Bristol by the name of "landscape-marble," and which makes a very good hydraulic cement.



ARBORESCENT ARGILLACEOUS LIMESTONE, FROM THE LOWER LIAS, COTHAM, NEAR BRISTOL.

It takes the name of landscape-marble from its giving an outline of trees and figures, &c.; with a lively imagination, it is possible to make out small pictures on a piece of this kind.

Limestones from the oolite formation, as from the Isle of Portland, are used very extensively in London as building-material, and may be observed in the walls of St. Paul's Cathedral, many of the City churches, Somerset House, and other large buildings.

The cretaceous formation is one that affords, in its upper beds, a beautiful variety of almost pure carbonate of lime, which in this country is very white (chalk), but in Germany is occasionally of a dark colour, inclining to black, very different from English chalk; but the characteristic fossils are the same.

Limestones occur in the tertiary formation; such as the building-stone of the northern part of the Isle of Wight.

Limestones and marbles are found abundantly in Ireland, and, less so, in Scotland.

As limestone often resembles sandstone in many of its appearances, the question is frequently asked, How can a piece of limestone be distinguished from a piece of sandstone? It is easily distinguished; first of all by its being acted upon readily by acids. A little diluted hydrochloric acid will cause an effervescence when applied to any of the forms of carbonate of lime; it will not do so when applied to sandstone. Another simple means of testing it, is to take a piece of common glass; draw a limestone over it, it will not scratch it; draw a sandstone over it, and it will. These are simple tests by which any person can ascertain the nature of these minerals.

Different limestones vary greatly in durability. The magnesian limestone is very useful for its resistance to the weather, whilst some of the oolites are perishable. The degree of fitness of different limestones for building-purposes is perceptible in the Houses of Parliament, where some of the mouldings on the outside of the edifice have decayed and others not been injured, according to the description of stone employed. The oolitic stone used in the colleges at Oxford also affords an illustration of unsuitable materials for particular work. From the appearance of many of the buildings, a person might suppose they were two or three thousand years old, whereas the most ancient are not above two hundred.

I might continue these general remarks at considerable length, on the application of limestones for ornamental and useful purposes; but, as there is a discussion to follow, and another paper to be read, I will conclude with stating that I shall be happy to answer any inquiries.

In the discussion which followed, Mr. C. H. Smith said allusion had been made to some of the materials used in buildings. Now, it generally happened that, in the neighbourhood of a town, the choice was between clay or stone, and that where clay was abundant, stone was scarce, and *vice versâ*. Of this fact he gave two or three instances. He spoke of the great cost of stone in early times, owing to the deficiency of means of carriage, and described the stone that was brought in former days from Reigate and Godstone, for the construction of the principal buildings in London. Of these buildings, he said, there were now scarcely any parts remaining; some of the upper portions of Westminster Abbey, about the cloisters, and the interior parts in Dean's Yard, were the only relics. Sir

Christopher Wren, speaking of Westminster Abbey in his day, described it as having mouldered away four inches from its original surface. Another thing, he said, was remarkable in the buildings of the middle ages—namely, the smallness of the stones used—stones, in fact, that could be pulled up by ropes by one or two men. He compared with these the immense masses at Stonehenge, some of which were now standing out of the ground as much as 16 feet, and must, of course, be many feet under the ground as well. These again had enormous stones on the top of them. He then spoke of a column at Rome, composed of stones of enormous weight and size. He said that materials from the greensand formation continued in use till about the year 1618 or 1619; after which, the Portland stone was generally used, until, from the want of competition, the builders used it of such a vile quality, that it brought about the inquiry into different kinds of stone for the construction of the Parliament Houses.

A member asked Professor Tennant if there was any great difference between the black chalk of Dresden and the white chalk.

Professor Tennant replied that the difference in colour was caused by a little animal matter. The Professor then alluded to a black marble obelisk brought from Nineveh by Mr. Layard, which, he said, was precisely similar to marble from different parts of Derbyshire. He cited an instance of black marble becoming bleached, and said it was caused by the bituminous matter being expelled. He explained the process by which the chemist procured pure carbonate of lime from this black marble—namely, by expelling all the animal matter from it by heat. He said there was a peculiar property in this description of marble, which caused it to be called "stink-stone." Two pieces of it rubbed together produced a very bad odour, which was caused by the sulphuretted hydrogen evolved during the friction.

Mr. Cresy pointed out the importance of ascertaining the relative durability for building-purposes of different descriptions of limestone. He alluded to the Commission appointed by Government for the purpose of examining into the best material to employ for the Houses of Parliament, and said that they travelled over the length and breadth of the land, and collected a great quantity of specimens. There was a considerable amount of scientific power, both mineralogical and geological, represented on that Commission, and yet the result had been of a very unsatisfactory character, as was obvious to all. He compared with the Houses of Parliament some of the earliest of our mediæval buildings, constructed without mineralogical or geological knowledge, taken from formations which are now considered to yield stone of comparatively short duration for building-purposes, and yet which are gifted with an extraordinary power of preservation. He said that the members of the Geologists' Association, while travelling over different parts of this island, would do well to turn their attention to this subject; and where they found an old building, the date of which was known, that they should endeavour, by the fossils imbedded in it, and by its mineralogical characteristics, to identify the stone with some quarries in the vicinity, and that they should favour the Association, on their return to town, with a report of their investigations. He thought Professor Tennant, and the more scientific members of the Association, might also throw a great deal of light upon this subject by giving mineralogical and chemical analyses of those stones which possessed the greatest amount of durability; and that they might particularly address themselves to those scientific tests which could be applied by modern architects with the greatest facility.

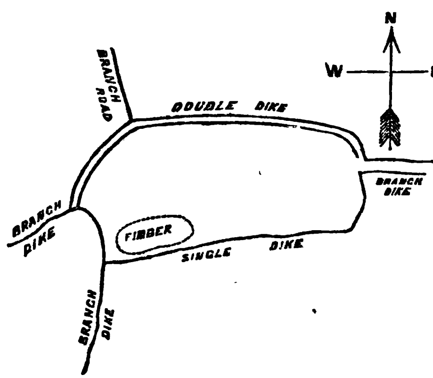
Professor Morris said that he quite agreed with the practical remarks of Mr. Cresy, and added that limestones may be regarded from three points of view—mineralogically, chemically, or geologically. Taking them from the latter, he might observe that Professor Tennant had hardly adverted to the limestones of the Silurian and Devonian formations; yet he thought that, with regard to the limestones of the Devonian series, some remarks might be made about them which would be interesting to the Association. For example, in the neighbourhood of Plymouth and Torquay, there are limestones which are employed not only for lime-burning, but for ornamental purposes; indeed, many of the Devonian limestones are of high ornamental and practical use. Some of the best limestones of this formation which he had met with are in the Pyrenees, where they are found highly indurated and compact, the preparation of them for the English and American markets giving employment to a large number of persons in the locality. In some of them the goniatites of the palæozoic period are very plentiful, as they also are in the Devonian limestones of Prussia and Bavaria. Again, in the valley of the Saal, near Saalfeld, there occurs the same limestone formation as that of the Pyrenees, and there are many other localities in which its existence might be pointed out. The lias yields a durable limestone which had been used in the construction of the refectory of Glastonbury Abbey. The oolitic group affords more or less durable stones, as the free-working shelly and oolitic limestones of the inferior and great oolite, the coral-rag, and the well-known and extensively worked Portland limestone. There is the Wealden limestone, or Petworth marble of Sussex and Kent, too, which is alike interesting in an architectural and in an antiquarian point of view; and mention might be made of the Purbeck marble, and which has also been much used as an ornamental stone in the earlier ecclesiastical edifices. Professor Morris further observed, that allusion also might be made to the Nummulitic formation, a member of the lower tertiary strata, which in this country, as at Bracklesham, consists of incoherent sandy clays; in the Paris basin it is a more compact rock, but in the south of Europe forms a kind of marble, and this rock extends for a great distance, from the Pyrenees to Egypt, and even to India; the pyramids are partly constructed of Nummulitic limestone. The eocene fresh-water limestones of the Isle of Wight have been also largely worked, and the "calcaire grossier," a limestone of the same geological period, is, as is well known, a building-stone exclusively used in Paris and the neighbourhood. Mr. Cresy had directed the attention of the geological tourist to the examination of the stones of which the ecclesiastical edifices in the locality they might be in were built; to this he would add, that they should also pay attention to the internal decorations, where they would find much to interest them in connexion with the limestones. Mr. Tennant had referred to black chalk found in the neighbourhood of Dresden; but, as he was quite unacquainted with such a deposit near there, he would be glad to learn the precise locality. He quite agreed with the view that if the student was more acquainted with field-geology, instead of books, his knowledge of the science would be more sound, and he believed the tendency of the Geologists' Association was to render the study of Nature, so far as geological subjects were concerned, much more popular. With regard to the cause of the durability or non-durability of the marbles and limestones, he would advise all interested, whether as a mason, as an architect, or as a geologist, to consider that it is probable that since the deposition of these strata, the changes which they had undergone had been very various, being in some cases merely mechanical alterations, in some chemical alterations, and in some mechanical and chemical alterations combined; he reminded them of these facts, because he believed the study of the origin of the materials, and the processes by which they were subsequently consolidated, were the readiest means of enabling an opinion to be formed with regard to their more or less rapid disintegration.

Mr. Tomlinson said that the principal cause of surface-disintegration being the absorption of water and its subsequent freezing, it was important to ascertain what stones would resist the action of frost, and this could be done by Brard's method, which was to boil the specimens in a saturated solution of sulphate of soda, and then hang them up in a dry air. The salt in crystallizing would pretty accurately represent the force of water in freezing, and would chip off portions of the stone. These fragments being collected and weighed, would represent numerically the resisting powers of the stones, the smallest numbers representing the greatest powers of resistance.

Professor Tennant, in thanking Professor Morris and the other gentlemen who had taken part in the discussion for the information they had communicated to the meeting, remarked upon the able manner in which Professor Morris had spoken on the subject, and explained that his omissions arose rather from his object having been to confine himself to the limestones of the British Islands, than from any failure to recognize the importance of those to which Professor Morris had referred. In our own country there were instances of the practical application of limestone,—in the cathedrals of Canterbury, Chichester, Salisbury, &c., for examples equal to any. At the Society of Arts, in the large lower room, there was one of the best collections of marbles which could be brought together; but, from the little attention that was paid to them, they had been permitted to get so dirty that they could not be seen, and he one day actually saw a man chopping wood on one of the finest specimens. At the Museum of Practical Geology there was also a fine collection. If any of the members were passing the news-rooms at 76, Strand, they would find a very beautiful collection of the Pyrenean marbles which Professor Morris had been speaking of. Reference was also made to the visit made by many members of the Association to the new Museum at Oxford last year, when Professor Phillips kindly pointed out the characters of the several beautiful columns which enter into the structure of the interior, and which have been obtained from different parts of the British Isles. The Professor (Tennant) also alluded to the damage done to limestone structures by the use of iron tyes, which oxydized and expanded, splitting the stone in which they were inserted.

2.—" On the Ancient Flint Implements of Yorkshire, and the Modern Fabrication of similar Specimens." By the Rev. Thomas Wiltshire, M.A., F.G.S., &c., Vice-President.

Towards the north-western side of the hilly district of Yorkshire, known by the name of the "Wolds," and cut through by the old coach-road from York to Bridlington, are the remains of an ancient intrenchment which once completely encircled, though at some distance, the small village of Fimber. This earthwork, which was perhaps in part planned by the



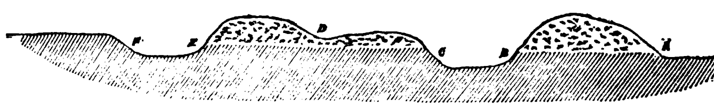
RESTORED PLAN OF THE INTRENCHMENT AT FIMBER, YORKSHIRE.

Brigantes,* or an earlier tribe, and subsequently more fully developed by the Romans,† exhibits the signs of much forethought in its construction,

* This people, inhabiting the region between the Trent and the Tyne, and described by Tacitus as being very numerous in population and warlike in character, were first completely subdued by the Romans about the year 71 A.D., in the reign of the Emperor Vespasian (Tac. vit. Agr. 17). A previous and more partial attack on their territory had been also made by the Romans in the year 50, during the reign of Claudius (Tac. ann. xii. 32).

† About five years since, some workmen employed in making an excavation at the base of the larger wall of the northern double dike found buried in the soil a copper coin, much defaced. The coin, which has been obligingly forwarded to me by its owner for inspection, proves to have been one of the very many struck by Carausius, during his brief reign as Roman Emperor in Britain, between the years 287 and 293. It is of the " pax " type, and has on the one side a female figure holding a branch and spear, and on the other a head with a radiated crown, and is much the same in appearance as several referred to in Dr. Stukeley's very curious work, " The Medallic History of Carausius." The legend is illegible.

and the proofs that it was a place of no little importance. It is seen, when carefully examined, to have been originally almost quadrilateral in form, of a length of more than a mile in extent, and of a width of more than half a mile, and to have had connected with it three ramparts or "dikes"* (to use a local term), which were carried on not always in straight lines, but often with many bends and curves, in the direction of York, Market Weighton, and Bridlington. On the north there is evidence of a military road leading towards Malton. The portions of the earthwork best fortified were the whole of its northern half under the hill; here a double fosse and double dike existed; but on the southern half only a single ditch and single rampart. The double fosse and double dike were not confined to protecting the intrenchment, they were also employed as a defence to the ground to the east, for it will be perceived that about midway on the eastern side they suddenly turn off nearly at a right angle from the main body of the fortification, and proceed in an easterly direction.



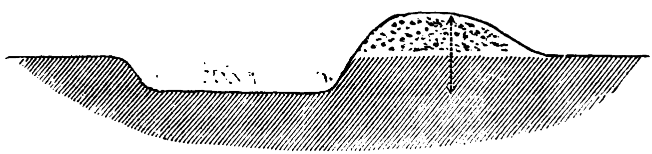
SECTION OF THE DOUBLE DIKE.

Scale 10 yards to the inch.

The general characters of the double fosse and dike are well shown in this radiating branch, and are sketched in the woodcut above, which gives a section (drawn to scale) of them, as they now appear, at about 150 yards to the east of the intrenchment. They consist of two mounds A B and D E, two ditches B C and E F, and a made way D C. The mound A B is rather more than 5 feet in height on the side away from the ditch B C, and the mound E D rather less than the side next the ditch E F. The width of A B,

* The word "dike" has two opposite meanings in Yorkshire. In the higher lands it signifies that which is raised for the purpose of a boundary, as a wall, or long mound of earth; but in the low, marshy grounds, it is applied to that which is excavated, and then has reference to ditches, canals, becks, and rivers. See Professor Phillips' work on "The Rivers, Mountains, and Sea-coast of Yorkshire," where a vast amount of information on the geology, natural history, and antiquities of Yorkshire may be found.

B C, and D E, is 22, 14, and 17 feet respectively; the length from A to F, the whole extent of the section, is about 28 yards. This double dike * is also well marked in the plantation near the railway station, where I observed, when I visited Fimber last autumn, that even at the present day a man standing near the breastwork would be greatly shielded from the missiles of an enemy attacking on the outside. The single dike and ditch forming the southern half of the intrenchment is less conspicuous, and is only visible in places—as, for example, on the eastern side, where the sketch for the woodcut was taken, and where the ditch is about 12 feet wide, and the rampart from 4 to 5 feet high. Both the double and single dike have the ditch on the outside of the fortification.



SECTION OF THE SINGLE DIKE.
Scale 4 yards to the inch.

The effects of weather, of time, and of agricultural operations have contributed to obliterate many parts of the intrenchment; but those portions

* Although there are various ancient intrenchments in England which have double ditches and ramparts like that at Fimber, and which have been usually accounted Roman, it appears, from the writers of antiquity, that the ordinary custom of the commanders of the legions, when constructing both permanent and temporary camps, was simply to throw up only a single rampart and dig a single ditch, and not to form more complicated works. Vegetius, in his treatise on military affairs, gives express directions on this point (i. 24; iii. 8). Josephus, in his History of the Jewish War, mentions the same practice on the part of the Romans (iii. 5, sec. 2). Very many incidental remarks in Cæsar (Bell. Gall. ii. 5; iii. 1, &c.), Livy (Hist. ix. 14; xxv. 36, &c.), and Tacitus (Ann. i. 61; i. 68, &c.), agree in confirming the statements of Vegetius and Josephus. May not those intrenchments which are of a character different from that spoken of by the above-named authors have been the work of the native tribes whose territories the Romans finally acquired by conquest? That some of the semi-barbarous tribes could and did execute earthworks is often alluded to, and is remarkably well shown in Cæsar (Bell. Gall. v. 42), where it is stated that the Nervii, a people of Gallia Belgica, without a proper supply of iron tools, but using their swords for spades and their cloaks for baskets, raised in less than three hours a fortification ten miles in circumference.

which have been removed by these causes still have left their trace, by affecting the crops and vegetation—a change in the colour of the grass marking the line where the mounds once existed.

I dwell upon the earthwork because the facts in connection with it show it must have been once a strongly fortified place, where there would probably have been numerous conflicts, especially on the lowest side, and where many of the weapons of the contending parties would, after the action had terminated, remain buried in the earth. These latter suppositions are found to be correct. The soil about the fortification abounds even now in weapons of a rude class, and very different from those of the present age. There it is that flint implements, wearing the appearance of antiquity, formed with care, chipped into determinate shapes, and evidently made for the purpose of destroying life, occur. Mr. Robert Mortimer, a resident at Fimber, and a member of the Association, to whom is due the credit both of determining the original form of the intrenchment (the ground-plan is only partially laid down in the Ordnance-map), and of observing the presence of the flint implements around the village, has been at much pains to secure the preservation of such examples as were from time to time discovered. The result has been that, within a comparatively short period, he has been enabled to collect a considerable number of these ancient weapons, sufficient in extent to show that the great majority could not have been produced by natural causes, but must have been fashioned by design. This gentleman, who has obligingly forwarded his collection for inspection,* in answer to some questions relating to the persons by whom the flint implements were discovered, the places whence they were obtained, and the total number found, writes me word as follows:—"All these" (there were 268 sent for exhibition) "were found by myself, or children under my direction, during the last *two* summers, whilst engaged in farming-operations in the fields (surface mostly) around Fimber. They were obtained near the dikes, always most plentifully on the outside, on the eastern and south-western sides, but occasionally within. The flint implements are much more easily found in dry weather, during summer, than they are in autumn or early in the spring; dirt does not adhere to them so much when the soil is in a dry state."

These particular weapons are of value from the facts connected with

* A large number were exhibited at the meeting.

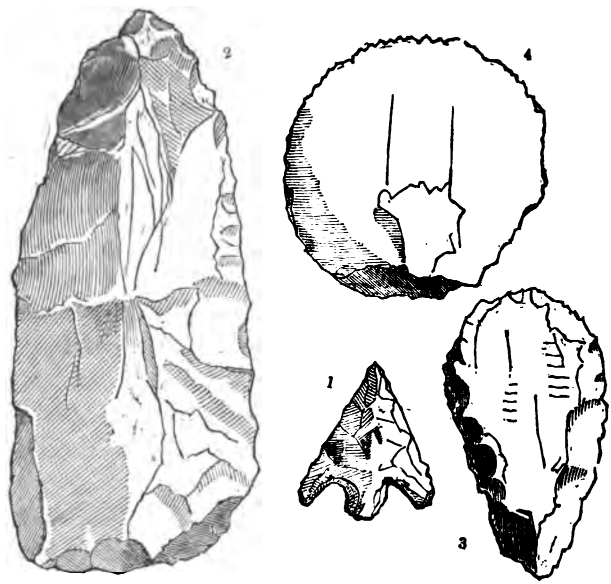
their discovery, which separate them from many other specimens to be met with in museums. Their position in the ground is well defined, and differs from the weapons of the gravels; they are also genuine and authentic, and are free from those sources of error which occasionally invalidate the testimony of specimens which are said to be the work of antiquity. It will be observed, from Mr. Mortimer's remarks, that they were in the upper soil, and must have been turned up by the plough; that they were either contiguous to, or at a short distance from, the walls of the intrenchment, and had not been moved afterwards from the place where they had fallen; and it will be noted, they are genuine—that they have neither passed through dealers' hands, nor have an uncertain history, but have been picked up by one who lives on the spot, and who, by the very fact of residence, would not be liable to be deceived. They occur also, it will be seen, under conditions very unlike that which appertains to the flint weapons of the gravel of the South of England. The last are usually obtained from undisturbed strata of gravel and sand, in which shells and bones are imbedded, and which appear to have been once under the action of running water, which probably gathering the bones and shells * and flint weapons from different localities, at last deposited them together in the places where they are now met with.

Fimber, however, is not the only locality in Yorkshire where the flint implements are abundant. At Bridlington, I was shown by Mr. Tindall, another of our members, a large collection which he had formed during, I think, a space of thirty years, from the land around that town and its neighbourhood, and he said that he was continually meeting with new specimens, which were brought to him by different persons. The same holds good on the Yorkshire Wolds generally. I believe, in fact, tha the high chalk regions of Yorkshire, which, especially on their northern and western borders, abound in intrenchments, in tumuli (they are to be seen by hundreds over the loftiest heights), and in ancient roads, under the sides of, and protected by, the hills, are great storehouses for the preservation of these curious weapons.†

* In some cases, the shells which belong to lake and river species, appear not to have been transported from a distance, but to have lived and died near the place where they are now found.

† Professor Phillips, in his book previously mentioned, describing at page 41 the Wolds, and alluding to the beautiful panorama from Leavening Brow, the most

In this woodcut are figured four of the most definite forms of the flint implements from the intrenchment at Fimber. The drawings are of the natural size of the specimens themselves, and may be taken as representing types of four great classes, which, although containing specimens of varying size, continue to preserve the same general outline.



Flint Implements from the Ancient Intrenchment at Fimber, Yorkshire.

Fig. 1 is clearly the head of an arrow; the original is of an inch

westerly extremity of the chalk range of hills in Yorkshire, about eight miles from Fimber, thus eloquently refers to the past generations that peopled the region:—"Everywhere these hills present a smooth, bold front to the north and west; and from a point like Leavening Brow, which commands views in both directions, the prospect is singular and delightful. An immense vale sweeping round, with the great tower of York Minster for its centre; in the south, the gleaming waters of the Humber; on the west, the far-off mountains; to the north, the dreary moorlands; while immediately surrounding us are the green Wold hills, crowned with the tumuli and camps of semi-barbarous people, who chased the deer and wild boar through Galtres Forest, watered their flocks at Acklam Springs, chipped the flint, or carved the bone, or moulded the rude pottery in their smoky huts, and listened to warriors and priests at the mound of Aldrow, and the temple of Goodmanham."

thick, and $\frac{6}{8}$ of an inch long; the interior of the barbs, next the shaft, is bevelled off and rounded in a way which seems very hard of execution. These arrow-heads all bear the same character, and exhibit considerable care in their production. They are by far less common than any of the others implements.

Fig. 2 is probably a spear-head; the weapon itself is an inch thick, wedge-shaped, with a comparatively flat base and bevelled sides, running down to a rough point at the other end. It is nearly 3 inches long. This kind is common, and is more subject to greater differences of size than the preceding, some examples being rather larger and others rather smaller than that in the woodcut.

Fig. 3, leaf-shaped, possibly another spear-head, belongs to a class much less rough-looking, and more carefully worked than those of Fig. 2, and is distinguished from them by a circular, instead of flat base. In the specimen figured the edges are bevelled; one end is pointed and the other curved; the diameters are $\frac{6}{8}$ and $\frac{12}{8}$ respectively of an inch, and the thickness $\frac{3}{16}$ of an inch; it is of the usual size of this variety.

Fig. 4, in all probability a sling-stone, represents a class which is circular, having one part of the circumference rather flat (shown in the shaded part of the drawing), thin, with bevelled edges, and which contains various sizes, from $\frac{12}{8}$ of an inch in diameter to $\frac{6}{8}$ of an inch; it is very abundant. The original is $\frac{1}{4}$ of an inch thick, and $\frac{10}{8}$ in diameter.

Mr. Mortimer, alluding to the drawings, writes that Fig. 1 is the rarest, and Fig. 4 the most common shape; and that if the four classes described were to be valued according to the per-centage of the whole number found, they would then stand (commencing at those of which Fig. 1 is the type) in this order—1, 3, 7, and 60; he considers also that the rarity of the arrow-heads (Fig. 1) is partly due to their small size, and to their liability of being concealed by dirt and overlooked.

Besides these figured, there are other less definite forms, which may arise from natural causes, for the flint in this part of Yorkshire easily shatters, and often takes strange shapes. Amongst them are cone-like pieces, flat at base, with a circular circumference, and pointed at the opposite end (an inch and a half is the ordinary size); roughly spherical nodules, about $2\frac{1}{2}$ inches in diameter; ridged-roof-like flakes, about 2 inches in length and half an inch in breadth, flat at one end and pointed at the other; flakes similar to the preceding, but less thick; saw-like pieces, &c.

In a Yorkshire tumulus six miles from Fimber, where a human skeleton and the horns of a stag were discovered, was found a squarish-shaped stone, 3 inches in length, but longer than wide; it appears to be chert from the mountain-limestone, and differs altogether from any of those from the field-intrenchments.

All the specimens (omitting the single one mentioned above) possess that appearance which is presented in flints that have been lying about in the fields for very many years, viz., a certain degree of polish over the whole exterior, and a white coating on the outside, which in some cases is only just on the surface, giving it a mottled aspect, and in others has penetrated so far below as to become uniform in tint. The implements are generally light-coloured (there are exceptions), of a greyish shade, such as is seen in the flints of that part of Yorkshire, and very different from the almost black flints of Kent and Sussex.

In point of time they date back necessarily to an early period, probably not much less than two thousand years*—possibly much more—yet they must be long subsequent to the flint implements of the gravel of other neighbourhoods; the latter, it will be remembered, are met with at considerable depths, ranging from 9 to 20 feet, whilst the former, from Fimber, are turned up by the plough.

In various tumuli† which in the course of years have been opened at Gristhorpe, at Driffield, at Ackham Wold, &c., flint arrow- and spear-heads, together with instruments of bronze, have been found; and evidence has been afforded that the art of working glass, gold, and iron was not unknown amongst the Brigantes; but the age of these particular remains from the

* Tacitus, in his remarks upon the condition of the German and British tribes of the first century of the Christian era, bears testimony to the comparatively small number of metal weapons of defence which existed amongst them; he speaks repeatedly of their using spears of wood with the points hardened by fire (Ann. ii. 14; iv. 51); of their being inferior to the Romans, not in courage, but in arms (Ann. ii. 21; iii. 43); of swords and large lances being seldom seen (Germ. vi.); of missile weapons being common (Ann. xii. 35; Hist. v. 17); of helmets and coats of mail being wanting, and of their shields being not defended by iron (Ann. ii. 14; Germ. vi.); and he infers, in a remarkable passage, that the Germans were then using warlike implements of flints and stone; for he writes, "Ne ferrum quidem superest, sicut ex genere telorum colligitur" (Germ. vi.)

† The contents of a large number of barrows opened in Yorkshire will be found in "Ten Years' Diggings in Celtic and Saxon Grave-hills. By Thomas Bateman. London, 1861." Pp. 204—241.

tumuli is uncertain, and they afford no assistance in determining the date of the flint implements under consideration. There is, indeed, in Yorkshire, a want of clear lines of demarcation between the iron-, bronze-, and flint-ages—lines which are afforded in other countries on the Continent, where, in digging in peat-bogs, iron weapons are nearest to the surface, then bronze, and lastly flint; and each of the three are so situated, with marked changes in the condition of the forests that prevailed when they were made, as to give a very great antiquity to the people by whom the flints were fashioned into form.

The Yorkshire flint implements differ in various particulars from those which, in other places, are found much deeper in the soil; they are smaller, of another shade of colour, contain greater variety of form, and are not exactly of the same shape. For example, the average length of the specimens obtained from the gravels of England and France is about 6 inches; of those from Fimber not more than 2 inches. Again, the Suffolk and French examples are of a different description of flint, being not of the bluish-white tint of the Yorkshire specimens, but darker, with the coating of the surface more strongly charged with oxide of iron, and more thoroughly altered by effects of weathering; and finally, the implements in gravel seem to be chiefly fashioned after one type, which is rhomboidal in outline, with the angles of the shorter diameter not in the middle of the longer, but about three-fourths down, and so constructed as to be very strong and to present an appearance intermediate between Figs. 2 and 3, but larger.

The Yorkshire specimens have their representatives, both as to size and shape, but not as to tint or colour, in Ireland, from whence many arrow- and spear-heads have been obtained. In the Gallery of British Antiquities in the British Museum may be seen several dozen of the Irish flint weapons, together with a few of an earlier date and different type from the gravels of France and England. Amongst the latter is one about 6½ inches long and 4 inches diameter, of black flint, which was discovered with elephant remains in an excavation made years ago (near the year 1715) in the neighbourhood of Gray's-inn-lane.

How the implements obtained their present shapes, or how an ancient people without regular tools could have produced them from so intractable a material as flint, seem questions at first sight hard of solution; but that the means were at hand, and that the process was comparatively easy, is proved both from the numbers that have been found, not only at Fimber, within a couple of years, and over a limited area, but also from other places, and will be illustrated in the course of the evening by independent testimony. Through the efforts of Professor Tennant a person is in attendance who, with the aid of only a piece of small iron rod, bent at the end, will, with remarkable dexterity, produce almost any shape required; he can also work with a fitly formed stone.

The great interest which attaches to the Fimber specimens arises from the circumstances, as was observed above, of their undoubted authenticity, and their exemption from having passed through any dealer's hands. The discoveries by Mr. Frere,* at Hoxton, in 1797; by Dr. Schmerling,† at Liége, in 1833; by M. Boucher de Perthes, at Abbeville, in 1841 and 1847;‡ by Dr. Rigollot,§ at St. Acheul, in 1854; by Dr. Falconer,|| at the Grotta di Maccagnone, near Palermo, in 1858, where, it is stated, flints rudely shaped, yet clearly formed after a pattern, and occurring in large numbers were found in undisturbed gravels, or other deposits, at some depth below the surface, and associated with the bones of animals not now existing in the same countries—these discoveries gradually awakened public curiosity, and caused a few imitations to be manufactured from time to time. But it was not until Mr. Prestwich's¶ paper on the subject was read before the Royal Society, in May, 1859, that spurious examples of the flint implements began to be common. After that period the animated discussions which arose, and the many controversies which were written, as to the reality of the co-existence of man with certain extinct animals, fully aroused the public mind, and led to a general desire on the part of thinking persons to inspect, if not procure, these rude weapons of a past age. The great law of demand and supply then

* "Account of Flint Weapons discovered at Hoxne in Suffolk."—*Archæologia*, Vol. XIII., p. 204.

† "Recherches sur les Ossemens Fossiles Découverts dans les Cavernes de la Province de Liége."

‡ "De l'Industrie Primitive," and "Antiquités Celtiques et Antédiluviennes."

§ "Mémoire sur des Instruments en Silex trouvés à St. Acheul près d'Amiens."

|| "On the Ossiferous Grotta di Maccagnone, near Palermo."—*Quarterly Journal Geol. Soc.*, Vol. XVI., p. 99.

¶ "On the Occurrence of Flint Implements, associated with the Remains of Animals of extinct species, in beds of a late Geological Period."—*Philosophical Transactions*, Part II., p. 277, 1860.

operated, as in most other cases, and makers of false specimens, in England, Ireland, France, and Denmark, brought their own workmanship into the market, and sought to palm them off as genuine. This fraud has not escaped the notice of antiquaries, as the following letter, from a well-known archæologist, will show :—

"*Newington Place, Kennington,*
"*February*, 1862.

"MY DEAR SIR,—It is now some twelve years since that I first became acquainted with the fact of the existence of the Yorkshire flint forgeries. The late Mr. Thomas Bateman, in a conversation which I had with him in December 22, 1854, informed me that when he was in Yorkshire he visited the arrow-head-maker, and actually saw him at work at his vocation. And in my paper 'On Frauds in Archæology,' read before a meeting of the British Archæological Association, on January 24, 1855 (printed in our *Journal* XI., 67—73), I made a passing allusion 'to the basalt and flint celts and arrow-blades now manufactured in Ireland and Yorkshire,' which, brief as it was, was sufficient to direct attention to the subject, and open the eyes of many who had hitherto been blind to the real nature and origin of these so-called *primeval relics*.

"The examples of arrow-blades you have kindly sent me did not for an instant deceive me, for before I read your note, I pronounced them modern. They are, however, well and carefully made, but lack the time-producing patina, and, like several of the instruments from Abbeville which I have examined, have never been inhumed after fabrication.

"Yorkshire and Abbeville are not the only places which have yielded flint forgeries, for, on December 9, 1857, I brought to the notice of the British Archæological Society, an urn filled with arrow-heads and sling-stones, which was pretended to have been discovered on the top of Blackheath Hill. The flints were not near so well wrought as those from Yorkshire, and the urn was a most miserable thing of unbaked clay mingled with little pebbles and fragments of *red brick*.

"The vast heap of spawls and flakes at Northfleet—the refuse of a gun-flint manufactory—has, I fear, furnished the means of many a fraud, for here could, and perhaps still can, be obtained, blades of javelins, arrows, and knives, of various forms and sizes, sling-stones, and other articles without number. I felt that this mine of implements (which we may compare to the *Serro de los Navajas* of Mexico) are of such importance in an archæological point of view, that I called attention to it in our *Journal* (XIV., 95), and I trust with good effect.

"You are quite at liberty to print this notice of forgeries in flint, if you deem it to the purpose.

"Believe me, faithfully yours,
"H. SYER CUMING,
"Hon. Sec. B.A.A."

"To the Rev. T. Wiltshire."

In the forgeries of the flint implements there is a certain degree of roughness on the surface, and of sharpness on the edges, and an unweathered look about the whole, which is not perceptible in the true and genuine weapon; this is a distinction which is clear to the practised eye, though somewhat difficult to the unpractised.

That imitations are abundant, is worthy of being borne in mind, because although there is the highest testimony that weapons of flint were in use in very early times over a large extent of country, and may still be obtained whenever excavations are made in the upper soils and gravels, there is a danger, if due caution and circumspection be not used in the purchase of specimens alleged to have been found in likely places,—there is a risk of the spurious being accepted in place of the genuine, and of truth itself being falsified through the erroneous deductions which the presence of the modern fabrications may be made to yield.

The person who attended the meeting, as above mentioned, for the purpose of showing the mode in which flint could be easily formed into determinate shapes, was then summoned to the platform. The pieces of common flint, by means of a crooked bit of iron, soon became in his skilful hands, by what appeared to be most careless blows, well-shaped arrow-heads of various patterns.

Ordinary Meeting, Monday, February 3, 1862.

Professor Tennant, F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—J. P. Bidlake, Esq., F.R.G.S.; S. Bonsor, Esq.; Dr. Chance; H. Christy, Esq., F.G.S.; James Thorne, Esq.; G. H. West, Esq.; J. M. Wilson, Esq.; H. A. Wyatt-Edgell, Esq.

The following donations were announced:—

Land and freshwater shells from the Peat-beds of the Kennett Valley, near Newbury, Berks (26 species): Land and freshwater shells from the Grays, Essex (15 species): Marine shells from the Crag (68 species): by J. Pickering, Esq., Vice-President.

Abstracts of the Proceedings of the Geological Society, by the Geological Society.

The following papers were read:—

1.—"On the Cretaceous Group in Norfolk." By C. B. Rose, Esq., F.G.S.

I purpose giving a brief account of the Cretaceous group in the county of Norfolk, its course through the county, with some peculiarities in certain localities. I may here premise, that the outcrop of the beds of chalk forms a portion of the western margin of the great chalk-basin of Europe; its *strike*, or course, is nearly due south and north; and in the western division of the county, the outcrop of the Cretaceous group, including the Chalk, Chalk-marl, Upper Greensand, Gault, and Lower Greensand, forms two ranges of hills or downs, the eastern being the Chalk-range, the western the Lower Greensand range, with a valley between occupied by the Gault.

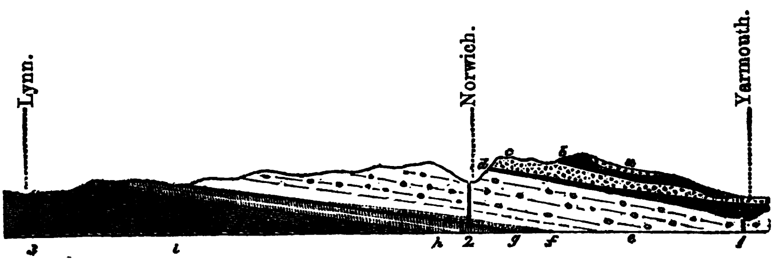


DIAGRAM-SECTION ACROSS NORFOLK.

a. Upper drift.
b. Boulder-clay.
c. Lower drift.
d. Crag.
e. Chalk.
f. Upper greensand.
g. Gault.
h. Lower greensand.
i. Kimmeridge clay and Oxford clay.

1. Sir E. Lacon's Well—	Feet.
Post tertiary beds	160
Crag	10
London clay	320
Woolwich beds	35
Chalk bored into	72
	597

2. Messrs. Colman's Well—	Feet.
Chalk with flints	1050
Chalk without flints	102
Upper greensand	6
Gault	24
	1182

3. Mr. Allen's Well—Kimmeridge and Oxford clay.... 665 feet.

The *dip* of the strata is at a very slight angle.* The late Mr. Woodward, author of the "Geology of Norfolk," published in 1833, divided the chalk beds into Upper Chalk, Medial Chalk, Hard Chalk, and Chalk-marl. His "upper chalk" and "medial chalk" comprise the "chalk with flints," the upper division of the chalk according to other geologists. This was a legitimate distinction, for the uppermost bed at Norwich contains organic exuviæ which are nowhere met with in the medial bed. His *hard chalk* is the chalk *without flints*, used extensively as a building-material, and also

* The *dip* as exhibited in the section is necessarily greatly exaggerated.

in sculpture; for in the church at Marham there exists a canopied monument, with two recumbent full-length figures, carved and constructed out of the hard chalk, and erected, in 1604, to the memory of John Stewart and Ann his wife, daughter of Humphry Shouldham, Esq.; the whole construction was evidently originally ornamented with water-colours (or distemper) and gilding.

The Upper Chalk.

I will first call your attention to Woodward's Upper Chalk; it may be traced from the Norfolk side of the River Waveney, opposite to Bungay in Suffolk, across the county through Norwich, on its way to the coast, where it may be seen in a highly disturbed state at Trimmingham and Cromer, and at Sherringham during low water. Its texture is much softer than the Medial Chalk; but it contains similar beds of tabular flint, some of them not more than 12 to 18 inches apart; generally they are from 4 to 8 feet asunder. The Upper Chalk, with its flints and organic remains, will be best studied at Norwich, where it is very extensively quarried, to be converted into lime.

The chalk beds in their entirety have been pierced through at Diss, and recently again at Norwich, by the enterprising spirit of Messrs. Colman, manufacturers of starch on a large scale, whose business required a softer water than the chalk strata afforded. If the report supplied to the Geological Society by the owner of the well at Diss be correct, and I have no reason to doubt it, it teaches us that there is great variation in the thickness of the chalk at not very remote distances, as shown by the sections at Diss and Norwich, which are not more than 20 miles apart; the latter well being nearly due north of the former, in the same *strike*, and at about the same level: for the former spot is near to the River Waveney, and the latter on the bank of the Yare.

The Section at Diss is—

	Ft.
1. Boulder-clay	50
2. Sand	50
3. Chalk *without flints*, soft and marly	100
4. Chalk with flints	330
5. Grey chalk without flints	60
6. Light bright blue chalk approaching to clay, with chalk-stones	20
7. Sand	5

The upper 100 feet of chalk *without flints* is a singular feature here, but not a solitary one.* If, as I am disposed to think, No. 6 is the Gault, and 7 the Lower Greensand, we have but 490 feet as Chalk with and without flints.

THE SECTION AT NORWICH IS—

	Ft.
1. Alluvium	16
2. Chalk with flints	1050
3. Chalk without flints	102
4. Upper Greensand	6 to 8
5. Gault, containing the characteristic small Belemnites, with Ammonites lautus and A. symmetricus, and numerous fragments of Inoceramus: not yet passed through ..	23

Here then is a thickness of 1152 feet of chalk; and if the highest surface of the chalk be added, which occurs at Mousehold on the opposite side of the Yare valley, and which I estimate as at least 40 feet above the *surface* of the chalk at the well, we have 1192 feet as the thickness of the chalk at this locality. The greatest thickness of the chalk in England previously recorded is 1300 feet; it occurs at Culver Cliff in the Isle of Wight, on the authority of the late Mr. Greenough. From measurements made in several parts of England, Mr. Conybeare gave between 600 and 1000 feet of thickness as an approximate result;† Mr. Wm. Phillips states the chalk with flints at Dover to be 480 feet; the chalk without flints 140 feet. "At Handfast Point, on the coast of Dorsetshire, the flinty chalk is 600 feet thick, and that without flints 200 feet" (*Greenough's Notes*).

At the Norwich well, the chalk with flints is said to be 1050 feet

* A chalk-marl without flints is the stratum which in Alum Bay, in the Isle of Wight, lies immediately next on the flinty chalk. It pulverizes with the frost; and, as the rains have washed it down, its situation is marked by a deep hollow. There appears also to be indications of its existence in the same position in other parts of the chalk-basin of the Isle of Wight; for in many parts of Sussex, South Siddlesham, South and North Bersted, Middleton, &c., there are pits of a marl, of the South Downs, as at Emsworth, Lavant, without flints, which is evidently over the chalk: the same marl has also been found in Dorsetshire, on the west of Corfe Castle; but it has not been discovered upon it in the London basin. (Mr. Webster; Geol. Trans. vol. ii. p. 178).

† For measurements of the chalk in the South-east of England, see Mr. Prestwich's remarks in the Journal of the Geological Soc., vol. viii. p. 256.—EDIT.

thick; the chalk without flints 102 feet: and I am quite disposed to rely upon the authority of the engineer, having questioned him very rigidly, and found him a well-informed man upon the subject.

It is not my intention to furnish a list of the organic remains of the chalk strata; suffice it to say, that they agree very much in kind with those met with in the chalk of the south-eastern counties; and comprise about 230 species in 100 genera, not including the fossils of the red chalk and blue gault; a large proportion of these are in my own collection. The fossils characteristic of the Upper Chalk at Norwich are, two species of *Belemnitella* in great abundance; *B. mucronata* and *B. lanceolata; Terebratula carnea; Rhynchonella octoplicata; Pollicipes* and *Scapellum*, very fine examples; *Ananchytes ovata*, of large growth, and of every variety; casts of three or more *univalves*, which I have not yet seen from the Medial Chalk; and *Cardiaster cordiformis*. Here also that singular fossil body, the Paramoudra, occurs in great abundance. In a chalk-quarry at Horstead, near to Norwich, they have been seen in a series of six or more in a vertical position, placed one upon another, and in contact. These bodies are believed to be sponges enveloped in flint, the original sponge resembling a recent one in the Indian seas, called Neptune's Cup. In the columnar example at Horstead, are we to suppose that those sponges originally grew from each other in the same manner as the cup-shaped spongoid bodies in the Yorkshire flints, as exhibited by Mr. Charlesworth at the Leeds meeting of the British Association? Paramoudras are exceedingly rare in the Medial Chalk. At Trimmingham the *Ostrea canaliculata* occurs in great abundance, with a large *Gryphæa globosa*, whose interior is frequently filled with flint. On the beach at Sherringham and Runcton, during low-water, there is to be seen almost a complete pavement of Paramoudras *in situ*. I measured the upper extremity of one, which proved to be five feet in diameter.

Upper Greensand. (Fossils wanting.)

Gault.

Belemnites minimus. | Terebratulina gracilis.

Red Chalk (Gault?).

Belemnites minimus. | Ammonites rostratus.
Inoceramus sulcatus.

Lower Greensand.

Nautilus radiatus. | Trigonia alæformis.
Thetis minor.

Medial Chalk.

The Medial Chalk may be traced from Thetford on the Lesser Ouse, through Weeting, Hilborough, Saham Toney, Swaffham, Castleacre, Litcham, Great Massingham, and Docking, to Wells on the coast. Its escarpment may be said to form the downs of Norfolk—the great sheep-walks of the western division of the county. It is a much harder chalk than that of the upper bed—in some places it is used for building-purposes; its beds of flint are arranged in the same tabular manner as in the Upper Chalk. At Thetford, cylindrical forms of flint from 18 to 24 inches in length are numerously distributed through the chalk; they are very sonorous, clinking loudly when struck against each other. Exceedingly thin seams of flint are seen at Thetford, Hilborough, and Wells; at the latter place, their course is at various angles between the horizontal plane and the vertical, as also seen between Brighton and Rottingdean, in Sussex. (*See* "Mantell's Fossils of the South Downs," plate 5.) Very perfect columns of octahedral crystals of sulphuret of iron are met with in the Medial Chalk.

Of organic exuviæ, with the exception of the *Terebratulæ*, the various *Inocerami* are the most abundant, the occurrence of which in Norwich is very rare.

Micraster is the predominant Echinite in the Medial Chalk; to this bed also belongs a rare sea-urchin, *Cardiaster excentricus*, of which I was so fortunate as to discover a small colony in the railway-cutting near Swaffham a few years since. A delicate *Avicula*, not yet figured, and which I have ventured to call *nitida*, is rather abundant at Wells.

Norfolk is not rich in the mammillated Echinites. Nor must she compare her remains of Fishes or Crustaceans with those of Kent and Sussex, either for number or perfectness.

A few vertrebræ and teeth of a *Plesiosaurus* have been found in the Upper Chalk at Norwich, also teeth of *Leiodon anceps*. Fragments of jaws, with teeth, of the *Ichthyosaurus campylodon* are preserved in the Hard Chalk from Stoke Ferry and Hunstanton. I also possess a tooth of *Polyptychodon interruptus*, and fragments of bone, from the Hard Chalk at Marham.

Hard Chalk.

The lower chalk, without flints, appropriately denominated by the late

Mr. Woodward Hard Chalk, it being extensively employed for building-purposes, may be traced from Hockwold, through Methwold, Northwold, Whittington, Stoke Ferry, West Dereham, Shouldham, Marham, Gayton, Congham, Flitcham, Shernborne, Sedgford, Ringstead, to Hunstanton Cliff. From the Lesser Ouse, the southern border of West Norfolk to Hockwold and Northwold, the Lower Chalk is hidden by the alluvium of that fenny district; at Whittington and Stoke Ferry in that neighbourhood it has been largely quarried; at the former place several *Ammonites* of the species *peramplus* have been met with,—I possess one two feet in diameter; at this locality *Holaster Trecencis* is rather abundant, the only place in the county at which I have found it. Among this order of organic remains, *Discoidea cylindrica* and *subucula* are here and at Stoke Ferry very common fossils; the small *Discoidea Dixoni* I have not yet met with in Norfolk. At both these localities, a small Spondylus, or Lima, with an obscurely reticulated surface, is rather abundant. *Pecten orbicularis* is a common fossil in the Hard Chalk. At Marham and Shouldham *Ammonites Mantelli* and *navicularis* are found. Here, also, and at West-acre, the *striated* surfaces seen at the natural horizontal junction of the beds are met with; and in a well at Swaffham, sunk through the Medial bed into the lower, that peculiarly polished surface called *slickensides* is well marked.

Two or three species of *Inocerami*, differing from those in the Medial Chalk, occur in the lower, viz., *I. mytiloides*, *striatus*, and *globosus* (nobis).

This summer I brought from Hunstanton a fine specimen of *Ammonites Austeni*, measuring two feet in diameter; and I possess *Nautilus Fleuriausianus* from the same locality.

Chalk-marl.

A grey bed at the base of the Lower Chalk denotes the position of the Chalk-marl; it may be seen in the large quarry at Stoke Ferry, where I found *Turrilites tuberculatus*, a characteristic fossil of the marl. At West Dereham, in a pit between the Grange farm-house and the church, this grey bed occurs, and is *there* filled with fragments of an *Inoceramus;* but this bed is best displayed in the cliff at Hunstanton, where it is found varying from two feet six inches to three feet in thickness; it is more arenaceous than the chalk above, and numerous knobs of whiter chalk are interspersed throughout it. Here, again, it appears to be almost entirely composed of fragments of an *Inoceramus* (probably *I. Cripsii*). I possess *Turrilites tuberculatus* and *Pecten Beaveri* from this stratum.

Ostrea carinata occurs in this bed, here and at West Dereham.

At Hunstanton Cliff a seam of stalagmitic carbonate of lime, in thickness from a line to half an inch, lies between this grey bed and the white zoophytic bed on which it reposes.

Upper Greensand.

The Upper Greensand, in a special form, does not occur as a distinct bed in West Norfolk, although in the well at Norwich it is found to possess the mineralogical character of that stratum in Wiltshire, and to have a thickness from six to eight feet.

There occurring no special bed of Upper Greensand between the lowest Chalk bed and the Gault at their outcrops in West Norfolk, and it (Upper Greensand) being met with in the deep well at Norwich, through a thickness of six feet, indicate that its deposit was not perfectly horizontal, but took place on a cup-shaped bottom,—in short, a basin of the Lower Greensand covered by the Gault; and that, as it was deposited upon this inclined plane, it is thicker towards the deeper part, thinning off towards the margin of the basin.

At the *outcrop* of the cretaceous beds, the Upper Greensand seems to represent the period of deposit of the Chalk-marl and Red Chalk (the Gault equivalent) beneath; for the animal exuviæ of the Chalk-marl, Upper Greensand and Gault are manifestly jumbled together in the two beds, Chalk-marl and Red Chalk.

At the Norwich deep well no fossils, or even fragments of any, have been observed from the Upper Greensand (at any rate none have been preserved).

In Hunstanton Cliff may be seen a bed of hard white chalk, 18 inches to 2 feet in thickness, composed almost entirely of a ramose zoophyte, its interstices filled up with calcareous matter; this is probably the equivalent of an Upper Greensand bed in the Isle of Wight, enclosing the *Siphonia Websteri.*

Between this stratum and the following one beneath is a seam of red ochre, three inches in thickness.

Gault.

Next in succession downwards lies a similar zoophytic bed* in two

* This bed is treated of at length in the paper on the Red Chalk of England by Rev. Thos. Wiltshire, formerly published in these proceedings.

strata, conjointly measuring four feet in thickness, deeply coloured by a red oxide of iron. The great abundance of small, highly polished pebbles interspersed through this bed, is another remarkable feature. *Belemnites minimus* and *B. attenuatus* abound in this red deposit. These two Belemnites, with *Inoceramus sulcatus*, which I possess from it, identify it with the Gault of the south-eastern counties; it also lies in the *strike* of the Blue Gault, which may be traced from the inland termination of the red bed to the fens on the southern border of the county. It contains also Upper Greensand *Terebratulæ*. Starting from the fens at West Dereham, the *Blue* Gault may be traced northward (except where hidden by a thick covering of *drift*), through Bexwell, Shouldham, Pentney, West Bilney, Gayton, Leziate, and Gongham, till it falls in with the red bed, previously mentioned, at Flitcham. This Blue Gault possesses the usual colour and tenacity of the Gault in other districts, and is also characterized by the prevalence of the two species of small *Belemnites*, and *Ammonites dentatus* and *lautus*; the large *A. rostratus* I possess from it. *Terebratulina gracilis* and a minute *Plicatula* are common fossils in it; and fragments of the column of a Pentacrinite (Fitton's Plate xi. f. 4; Geol. Trans., 2nd series, vol. iv.) are frequently met with. The blue Gault has been entered in the boring operations at Mr. Coleman's well at Norwich, from whence, with the small Belemnite, have been brought up fragments of *Ammonites lautus* and *A. symmetricus*, two species that I have found in the Gault of West Norfolk. A few Coprolites (?) are found in it at West Dereham.

Extensions (outliers) of the blue Gault, from the valley to the high ground westward, occur at Ryston, adjoining West Dereham, at East Winch, to the west of the church, on the Lynn road, and on a hill at Leziate, between the great road from Lynn to Gayton, and Pot Row, in the parish of Grimston.

Lower Greensand.

This deposit occurs in three forms in Norfolk. First, as a loose white sand, with seams of various shades of drab and ash-colour, its beds exhibiting examples of false stratification in many places. Secondly, a sandstone, characterized by the occurrence within it of numerous seams of a bluish oxide of iron, having a slight metallic lustre, and affecting a concentric arrangement, producing, in some instances, geodes. This stone is extensively used in the construction of buildings; it hardens on exposure, becoming almost imperishable. It is provincially called Carstone. The third form is a breccia, composed of small siliceous pebbles and angular fragments cemented together by ferruginous sand, and traversed by very thin seams of carbonate of lime. I estimate the thickness of the beds, conjointly, to be between 70 and 90 feet. The loose form of these beds occurs at Downham Market. At this place, six feet from the surface, there is a thin stratum of *fullers'-earth*, of an ash-colour, with ochry specks, and from 1 to 2 inches in thickness. These loose beds also may be seen at Shouldham Warren, Blackborough in Middleton, Bawsey, Castlerising, and Dersingham Heath. Here I have seen thin seams of lignite in the sand. The white sand is largely shipped for the glass-manufactories in the north.

In a quarry belonging to Sir W. Folkes, at the Short-trees plantation, there is a bed of pure white sandstone, which is used for the sills of windows and the lintels of doors. In the same quarry I observed, scattered through the sand, numerous spherical balls of ferruginous sand, from the size of a pea to that of a marble, giving a curious feature to the face of the quarry. The breccia associated with this formation can be seen only at Hunstanton, where an extensive section of it is exposed in the cliff, and it is seen in blocks upon the beach,—the latter, no doubt, retaining their original sites, the loose portions having been washed from them by the violence of the waves. Hitherto the breccia has been considered the base of the Lower Greensand at Hunstanton; but on a visit to that locality this summer, I detected a non-brecciated bed *beneath* the breccia, having the character of the bed *above* the breccia, with its seams of oxide of iron; and, at low-water, I saw it immediately reposing upon Kimmeridge Clay. It was from this lowest stratum of the carstone that the Rev. Thomas Wiltshire, your worthy Vice-President, took some Ammonites, rolled fragments of which had been previously met with on the shore by a resident of the lighthouse. There is a great paucity of organic remains in the Norfolk Lower Greensand; and it appears to me that those met with were chiefly confined to the undermost beds. Those that I have seen, and, indeed, possess, from Hunstanton and Middleton, are three species of *Ammonites*, one resembling *A. furcatus* of Fitton,* another ribbed like *that*, but a flatter species—probably *A. Deshayesii;* the third

* Trans. Geol. Soc., 2nd series, vol. 4; pl. xiv. fig. 17.

specimen exhibits the interior of the chambers only, and therefore the species cannot be determined. I have an anthozoan from the carstone of Hunstanton; its species unknown to me. From Dersingham I posses *Nautilus radiatus*, *Thetis minor*, and a *Cyprina*(?): from Downham, *Trigonia clavellata*, *T. alæformis*, and *T. spectabilis*, *Cyprina* (?), *Modiola*, a *Natica* similar to one from Black Gang Chine, in the Isle of Wight—they are all mere casts: also a *Stellaster*, with long rays—a very imperfect specimen, in hard carstone,—of which there is a drawing at the Museum of Practical Geology, Jermyn Street. I possess also from this place a specimen of *Zamiastrobus Fittoni* of Unger,* pyritous, with seed-cells open. Fossil wood occurs at every locality, exhibiting lithodomous casts.

In Norfolk, the Lower Greensand lies immediately upon the Kimmeridge Clay; no beds of the Wealden or Upper Oolite intervening; and it seems that, as we proceed from the south-west of the island, along the outcrop of the cretaceous group, towards its north-eastern termination, certain of its members are thinning out, and vanishing as they rise towards the surface; for whereas, in Cambridgeshire, the Upper Greensand is a special bed 18 inches in thickness, in *West* Norfolk there is no distinct stratum of it, although, at the depth of 1,150 feet, it is met with 6 feet in thickness at the Norwich well in East Norfolk. Again, the Lower Greensand, which at Hunstanton Cliff is of considerable thickness, with the Red Chalk (Gault equivalent) immediately reposing upon it, at Speeton, on the Yorkshire coast, has vanished, and the Red Chalk is in contact with the Kimmeridge Clay.

For a more detailed description of the strata included in this paper, I refer to my "Sketch of the Geology of West Norfolk," published in the "London and Edinburgh Philosophical Magazine and Journal of Science," for November and December, 1835, and January, 1836.

Characteristic Organic Remains.

UPPER CHALK (of softer texture than the Medial Chalk).

Leidon anceps—Norwich.
Plesiosaurus—Norwich.
Paramoudra, abundant—Norwich, Horstead, Sherringham, &c.
Inoceramus, giganteus.
Univalves, several genera.
Belemnites, very numerous.

* Trans. Geol. Soc., pl. 22, fig. xi.

MEDIAL CHALK.

Cardiaster excentricus—Swaffham.
Cardiaster cordiformis.
Inoceramus, 4 or more species very abundant.
Belemnites, very rare; in the upper chalk very numerous.

LOWER CHALK (with Slickensides).

Polyptychodon interruptus.
Ichthyosaurus campylodon.
Discoidea cylindrica.
——— subucula.

CHALK-MARL.

Inoceramus Cripsii.
Turrilites tuberculatus. Pecten Beaveri.

2.—"On the Plasticity and Odour of Clay." By Charles Tomlinson, Esq., Lecturer on Science, King's College School, London.

It is a happy result of Bacon's method of inquiry that science is not required to explain the causes of things, but to state the laws of phenomena. Nevertheless, while these laws are obscure, and facts are scattered, theory may often do good service by collecting and marshalling them: for, as our great master of induction well observes, "Facts are the soldiers, but theory is the general." And again, "Truth is more easily evolved from error than from confusion." That is, a bad theory is better than none at all, for it serves to collect and arrange the facts, and thus makes them more easy to handle.

In these remarks must be found my excuse to-night for endeavouring to bind together some of the facts respecting a property of a very common substance; namely, the Plasticity of Clay.

The more I consider this property the more wonderful and inexplicable does it appear. Take a mass of dry clay; it cracks easily, and crumbles readily: add to it a certain proportion of water, and it becomes *plastic*—it obeys the will of the artist or the artizan, who can, out of this yielding mass, *create* new forms, or perpetuate old ones. Drive off the water at a red heat, and plasticity is for ever lost; *rigidity* takes its place: the clay is no longer clay, but something else. It may be reduced to powder, and ground up with water; but no art or science can again confer upon it its plasticity.

All this is very wonderful. There is another fact that is equally so:

if we combine the constituents of clay in the proportions indicated by the analysis of some pure type of that substance, we fail to produce plasticity. I have on the table specimens of Dorset clays, dry and crumbling; the same wet and plastic; and the same in the forms of casts of fossils, which have been passed through the fire, and have exchanged plasticity for rigidity. They are, in fact, in the form of *biscuit*.

With respect to the temperature at which clay becomes rigid, we have no accurate information. It is much lower than is generally supposed, as will appear from the following experiment:—I pounded and sifted some dry Dorset clay, and exposed it to a sand bath heat in three portions varying from about 300° to 600°. Specimens were taken out from time to time, and rubbed up with water, but they did not lose their plasticity. Some clay was put into a test tube with a small quantity of mercury, and heated until the mercury began to boil. At this temperature (viz. 650°) the clay did not cease to be plastic. The flame of a spirit-lamp was applied, and the tube was heated below redness, after which the clay on being mixed with water, showed no sign of plasticity.

In experiments of this kind, the first action of the heat is to drive off the hygrometric water. The clay then becomes dry, but is not chemically changed; it does not cease to be plastic. On continuing to raise the temperature, the chemically combined water is separated, and the clay undergoes a molecular change, which prevents it from taking up water again, except mechanically. With the loss of this chemically combined water, clay ceases to be plastic.

It was, I believe, first noticed by Brongniart,* that we cannot produce plasticity by the synthesis of clay. The fire clay of Stourbridge, for example, is a hydrated silicate of alumina, represented by the formula Al_2O_3, $2\,SiO_2 + 2\,Aq$. If we mix one atom of the sesquioxide of alumina with 2 atoms of silica and 2 of water, we get a compound which cannot be called clay, since it is wanting in plasticity.

It is quite easy to obtain either alumina or silica in the gelatinous state; but we cannot obtain them in the plastic state.

Clay is almost the only substance in the mineral kingdom that possesses plasticity. In loam, if the sand be in large proportion, and in marl if calcareous matters abound, so as to deprive either material of plasticity,

* Traité des Arts Céramiques. Paris, 1844. Vol. i. p. 82.

it ceases to be clay. There are also certain silicates of alumina which are not plastic; such as bole, lithomarge, and fullers'-earth. Bole consists chiefly of a hydrated bisilicate of alumina, in which a portion of the alumina is replaced by sesquioxide of iron. Lithomarge also contains iron, and is sometimes so compact as to be used for slate-pencils. Fullers'-earth contains lime, magnesia, and iron, in addition to its principal ingredients.

There is probably no substance so indeterminate in its composition as clay. Regarding it, as Lyell does,* as "nothing more than mud derived from the decomposition or wearing down of rocks," it must necessarily contain a variety of substances; such as oxide of iron, lime, magnesia, potash, silica, bitumen, fragments of undecomposed rock, &c. These substances impair the plasticity of the clay, and impress upon it certain characters which are of more importance to the manufacturer than to the chemist, or the geologist. Brongniart† enumerates, and gives the analyses of no fewer than 167 clays and 28 kaolins, all of which are in use in the arts in different parts of the world. They probably all differ in plasticity, but they all possess it; and at a high temperature exchange it for rigidity. A rough method of measuring the plasticity of different clays is to note the length to which a cylinder of each can be drawn out in a vertical direction without breaking. In such a comparison, the clays must of course be worked equally fine, and contain the same proportion of water.

It is commonly stated that the ingredient that confers plasticity on clay is its alumina; and yet, strange to say, pure alumina alone, whether gelatinous, or after having been dried and ground up with water for a long time, never gives a plastic paste. Indeed nothing can be conceived less plastic than gelatinous alumina, as may be seen from the specimens on the table. We may drive off most of the water from this gelatinous hydrate, but it will not become plastic. Or we may form clay by mingling solutions of the silicate of alumina and the aluminate of potash. You see they are perfectly fluid. I apply the heat of a spirit-lamp, and we get an opalescent gelatinous mass, but still no plasticity. We have, indeed, formed a gelatinous clay.

* Manual (1855) p. 11.

† "Des Arts Céramiques," Atlas of plates.

We cannot say that the gelatinous state of alumina is the cause of plasticity in clay; for silica may be made as gelatinous as alumina, and silica is certainly not the cause of plasticity. It may be that the strong affinity of alumina for water (retaining a portion of it even when near a red heat) may be the cause of this property—just as turpentine renders wax plastic; and water and gluten confer the same property on starch.

We have seen that clay ceases to be plastic when its chemically combined water has been driven off. Still, however, water cannot be said to be the cause of plasticity, as a general property, since we have, in melted glass, a more perfect example of plasticity even than in clay; and few substances are more plastic than sealing-wax at a certain temperature.

A clear idea of plasticity, and of some of the other mechanical properties of matter, may probably be gained by considering them as variations of the forces of cohesion and adhesion, and by bringing these, in their turn, under Newton's great law of attraction directly as the mass, and inversely as the squares of the distances.

Now, if we suppose the distances between the molecules of matter to be 1-millionth or billionth, or 2, 3, 4, 5, 6, &c., millionths or billionths of an inch asunder, the intensity of their attractions will be 1, $\frac{1}{4}$th, $\frac{1}{9}$th, $\frac{1}{16}$th, &c., or, to represent it in a tabular form:—

Distances	1	2	3	4	5	6	7	8	9	10	&c.
Intensities of attraction	1	$\frac{1}{4}$	$\frac{1}{9}$	$\frac{1}{16}$	$\frac{1}{25}$	$\frac{1}{36}$	$\frac{1}{49}$	$\frac{1}{64}$	$\frac{1}{81}$	$\frac{1}{100}$,	&c.

Suppose the molecules to be of the same density, but at different distances apart, as represented in the upper line. At the distance of 1-millionth of an inch we get an intensity of attraction represented by 1. At 2-millionths of an inch the force of attraction is only one-fourth. Now, the idea is this, that the mechanical properties of matter,—such as porosity, tenacity, hardness, brittleness, plasticity, elasticity, &c., depend upon variations in the attractive force of the molecules according to the distances apart of such molecules. Thus, if the molecules of clay require to be 5-millionths of an inch apart in order to produce plasticity, the intensity of attraction between them will be represented by $\frac{1}{25}$th; but if such clay be passed through the fire, and the molecules, in consequence of the escape of water, be brought nearer together, and rigidly fixed at 4-millionths of an inch asunder, the force of attraction will then be $\frac{1}{16}$th.

Now, the method of arranging the particles of clay at that precise distance that shall impart plasticity, is one of Nature's secrets that we have not yet succeeded in penetrating. It may be that the circumstances under which clay is formed and deposited, or the time that has elapsed since its formation, or the pressure of the superposed layers, may have so arranged the particles as to enable them to become plastic when the proper proportion of water is added. It may be that a certain state of disintegration is required on the part of the alumina and the silica, so that their proximate elements shall be neither too fine nor too coarse; or it may be that the silica, in combining with the alumina, separates the atoms of the latter to precisely those distances required for the development of the property; or, lastly, the presence of a small portion of animal or other organic matter in clay may have something to do with this remarkable property.

Some experiments, which are now being conducted in France, show the presence of animal matter in quartz and various rocks, where its presence had not previously been suspected; and this may have as important an effect in modifying the properties of a mineral as the presence of minute portions of bodies, formerly entered as impurities, has in producing pseudomorphous crystals.

Still, the question recurs, Why is not a clay artificially formed from pure materials plastic? The answer is, that we do not know all the conditions of plasticity. We *do* know the conditions under which some mechanical properties exist,—such as the hardness of steel, the brittleness of unannealed glass,—and can confer or remove such properties at pleasure. But with respect to plasticity, we can only confer a factitious property of this kind on mineral substances by taking advantage of another property which it somewhat resembles, namely, *viscosity* or *viscidity*. Viscosity differs in plasticity in this, that the viscous body does not retain the form impressed upon it when the force is removed, as a plastic body does. The materials of the old soft porcelain of Sèvres had no plasticity; but this property was conferred by means of soft soap and parchment size.*

Without speculating further on the nature of plasticity, I may remark

* Brongniart (Des Arts Céramiques) says that the old *porcelaines tendres* were formed of 22 per cent. of fused nitre, 60 of Fontainebleau sand, 7·2 of salt, 3·6 of alum, 3·6 of soda, and 3·6 of gypsum. These materials were fritted and ground, and 75 parts taken, to which were added white chalk 17 parts, marl 8. This mixture was ground, sifted very fine, and made up into a paste with 1-8th soft soap and size, or, at a later period, with gum tragacanth.

that in the ancient philosophy the word was one of power. Derived from the Greek πλασσειν, or πλαττειν, "to form," or "to create," it not only included the arts of modelling in clay, but also sculpture and painting, and, by a refinement of language, poetry and music. Plato and Aristotle even supposed that a plastic virtue resided in the earth, or did so originally, by virtue of which it put forth plants, &c.; and that animals and men were but effects of this plastic power. They did not suppose the world to have been made with labour and difficulty, as an architect builds a house; but that a certain "efficient nature" (*natura effectrix*) inherent and residing in matter itself, disposed and tempered it, and from it constructed the whole world. Aristotle distinctly recognizes *mind* as the principal and directing cause, and *natura* as a subservient or executive instrument. Even in later times men have contended for the existence of a plastic nature, or incorporeal substance endowed with a vegetative life; but not with sensation or thought, penetrating the whole universe, and producing those phenomena of matter which could not be solved by mechanical laws. The learned Cudworth supports this view,* and the discussions into which it led him and other metaphysicians form a curious chapter in the history of the human mind. In England we do not now retain the term *plasticity*, except as a physical property of matter;† but in Germany it has still an extensive figurative meaning. The word *plastisch* still means *bildend* or *schöpferisch* (i. e. "creative"); and it is still applied not only to sculpture, but also to painting, poetry, and music. A German well understands the expression "plastische Gedanken," or "plastic thoughts."

Before concluding, I would refer to another property of clay, which seems to me as wonderful as its plasticity; namely, its *odour* when breathed on, or when a shower of rain first begins to wet a dry clayey soil. This odour is commonly referred to alumina, and yet, strange to say, pure alumina gives off no odour when breathed on or wetted. The fact is, the peculiar odour referred to, belongs only to impure clays, and chiefly to those that contain oxide of iron. This was pointed out by Brongniart as far back as 1816,‡ who also remarked that minerals which

* See "The True Intellectual System of the Universe," by Ralph Cudworth, D.D., 1678. A reprint has been published by Tegg, in which see Vol. I., p. 226, *et seq.*

† Dr. Johnson defines *plastic* as "having the power to give form."

‡ "Dictionnaire des Sciences Naturelles," art. *Argile.*

do not contain alumina, such as pulverized chalcedony, possess this remarkable property.

I have found that a pure kaolin, ground up in a mortar with a small quantity of water, emits a slight odour, which, however, becomes much more sensible if a little sesquioxide of iron be added.

Smooth quartz pebbles when rubbed together give an electric spark, and a fetid odour. It is commonly supposed that sea-side pebbles alone possess this property; but the odour belongs equally to those found among gravel overlying the chalk, and in ploughed lands where the surface is exposed to all the vicissitudes of the weather. It is quite possible that the odour of these pebbles may hereafter be traced to the presence of organic matter; but I cannot resist the reproduction here of a suggestive hint given me by my friend Professor Bloxam, who is reminded by the spark and odour from these pebbles of the presence of ozone.

What, again, is the cause of the odour in the narrow parts of stone buildings, not of new buildings alone, but of old ones, as in the staircases of old cathedrals?

I do not attempt to reply to these questions. It requires some amount of knowledge and experience to put them—but how much more to answer them!

A discussion followed, in which the President, the Rev. Mr. Wiltshire, Mr. Evans, and Mr. Cresy took part.

The President stated that the Committee of the Association, being fully persuaded of the benefit which the members would derive from having the opportunity to consult the publications of the Palæontographical Society (the MONOGRAPHS ON BRITISH FOSSILS), had resolved to purchase the same for the Library, and to request the co-operation of the Rev. Thomas Wiltshire and Mr. Rupert Jones in re-arranging in distinct monographs, and in a form suitable for binding, the various yearly volumes of that society; and that those gentlemen, having consented to carry out the wishes of the Committee, had not only done so, but had also drawn up the annexed table, which would both assist the members who might be subscribers to the Palæontographical Society in binding up their own copies in separate monographs, and further would show how large an amount of geological information of a most valuable description was now in the possession of the Association.

TABLE of the MONOGRAPHS, published by the Palæontographical Society, now in the Library of the Association. Those volumes marked * (fifteen in number) are complete and bound, and are ready for circulation amongst the members, subject to the Library-regulations.

SUBJECT OF MONOGRAPH.	Dates of the Years *for which* the Volume containing the Monograph was issued.	No. of Pages in each Monograph.	No. of Plates in each Monograph.	No. of Lithographed Figures and Woodcuts.	No. of Species described in the text.
The Mollusca of the Crag, by Mr. S. V. Wood:					
*Vol. I. (Univalves), complete	1847, 1855[1]	200	21	581	244
*Vol. II. (Bivalves), complete	1850, 1853, 1855, 1858[2]	344	31	691	253
*The Polyzoa of the Crag, by Prof. Busk, complete	1857	145	22	641	122
*The Tertiary Echinodermata, by Prof. Forbes, complete	1852	40	4	144	44
The Eocene Mollusca, by Mr. F. E. Edwards. Cephalopoda and Univalves, not complete	1847, 1852, 1854, 1855, 1858	332	33	578	161
The Eocene Molluscan Bivalves, by Mr. S. V. Wood, not complete	1859	74	13	188	70
The Malacostracous Crustacea, by Prof. T. Bell, not complete	1856	44	11	97	19
* { The Tertiary Entomostraca, by Mr. Rupert Jones, complete	1855	74	6	233	56
* { The Cretaceous Entomostraca, by Mr. Rupert Jones, complete	1848	41	7	176	27
*The Cretaceous Cephalopoda, by Mr. D. Sharpe, complete	1853, 1854, 1855	67	27	319	79
*The Great Oolite Mollusca, by Prof. Morris and Mr. J. Lycett, complete	1850, 1853, 1854	282	30	846	419
*The Fossils of the Permian formation, by Prof. King	1849, 1854[3]	288	29	511	138
*The Reptilia of the London Clay [and of the Bracklesham and other Tertiary Beds], by Profs. Owen and Bell, complete	1848, 1849, 1856[4]	150	58	304	39
*Fossil Cirripedes, by Mr. C. Darwin, complete	1851, 1854, 1858[5]	137	7	320	54
*The Reptilia of the Cretaceous formations, by Prof. Owen, complete	1851	118	39	262	18
*The Reptilia of the Cretaceous, Wealden, and Purbeck formations, by Prof. Owen, complete	1853, 1854, 1855, 1856, 1857	200	72	424	21
The Reptilia of the Oolitic formations, not complete	1859	16	7	40	2
*British Fossil Brachiopoda, Vol. I. The Tertiary, Cretaceous, Oolitic, and Liassic Brachiopoda, by Mr. T. Davidson, complete	1850, 1852, 1853, 1854	409	42	1,855	160
——— Vol. II. The Permian, Carboniferous, and Silurian Brachiopoda, not complete	1856[6], 1857, 1858, 1859	261	51	1,578	135
*The Oolitic Echinodermata, Vol. I., complete	1855, 1856, 1857, 1858	475	43	724	109[7]
*Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne, Edwards, and J. Haime, complete	1849, 1851, 1852, 1853, 1854	384	72	800	319[8]
		4,081	625	11,312	2,489

[1] Title-page to Univalves. [2] Note to Crag Mollusca. [3] Two corrections of Plates. [4] Supplement. [5] Index. [6] Contains the Permian, which is complete. [7] British Species only reckoned. [8] Many of the Species are described, but not figured.

The following are the Library-regulations :—

LIBRARY REGULATIONS.

I. That the library be open on the evenings of ordinary meetings, and that members be at liberty to borrow the books, &c., of the Association, subject to the following conditions :—

II. That no member of the Association borrow more than one volume at a time.

III. That unbound numbers of periodical works be not borrowed from the library; and that maps, plates, or drawings be not borrowed except by special leave of the General Committee.

IV. That the title of every book, pamphlet, map, plate, or drawing borrowed, be first entered in the library-register, with the borrower's signature.

V. That no work of any kind be retained longer than one month, except by special leave of the General Committee; but at the expiration of that period, or sooner, the same be returned free of expense, and it may then, upon *re-entry*, be again borrowed, provided no application for it shall have been made in the meantime by any other member.

VI. That in all cases the books, &c., or other property of the Association, in the possession of any member, be produced to the Honorary Librarian *on the evening of the July meeting in each year.*

VII. That in every case of loss or of damage to any volume, or other property of the Society, the borrower shall make good the same; and that any property shall be considered as lost which is not returned within four months after application for it.

There will be an excursion to Cambridge on June 10th, to examine the Upper Greensand, and on August 6th to Lewes, to visit the Upper and Lower Chalk. The President also proposes, during the period the International Exhibition is open, to give one or more lectures in the building, on the geological specimens and mineral products contained therein. Timely notice of the trains for these excursions and of the days for the lectures in the International Exhibition will be forwarded to the members.

The back numbers of the Proceedings of the Association (price one shilling each) may be had on application to the Honorary Secretary.

Letters and communications to the Honorary Secretary, W. N. Lawson, Esq., may be directed either to the rooms of the Association, 5, Cavendish Square, W.; or to 28, Chancery Lane, W.C.

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

No. 9.] [Session 1862–63.

Ordinary Meeting, Monday, March 3rd, 1862.

Professor Tennant, F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—Rev. R. W. Russell; Rev. H. Windsor, M.A.; Rev. W. A. White, M.A.

The following donations were announced:—

"*Abstracts of the Proceedings of the Geological Society*, No. 77"; and "*The Quarterly Journal of the Geological Society*, No. 68." By the Geological Society.

A cast of a Tooth of the Mastodon, from the Norfolk Drift. By C. B. Rose, Esq., F.G.S.

Fossils of various species. By Mrs. Stabb.

A paper was read,

"On the Fossil Remains of Vertebrate Animals." By B. Waterhouse Hawkins, Esq., F.G.S., F.L.S.

Mr. Hawkins, in a most lucid manner, demonstrated the great laws which exist in all the animal creation, and showed, that by analogy and induction, it was possible to build up a probable form from a mere fragment of bone.

On Tuesday, March 4th, the members visited the British Museum, when Prof. Rymer Jones made some interesting observations on Fossil Reptiles.

Ordinary Meeting, Monday, April 7, 1862.

Professor Tennant, F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—Thos. Adam, Esq.; John Alexander, Esq.; Rev. H. Brady, M.A.; John Brown, Esq., F.G.S; Rev. E. Crofton; Samuel Duer, Esq.; Rev. Thomas Greene, M.A.; Rev. Joseph Hambleton, B.D.; Rustamji Khursedje, Esq.; Arthur Lister, Esq.; Joseph Jackson Lister, Esq.; James Pye, Esq.; John Ruthven, Esq.; Marcus W. T. Scott, Esq., F.G.S.; E. D. P. Tewart, Esq.; J. Whiteley Ward, Esq.; James Woodward, Esq.

The following donations were announced:—

"*Stones of the Valley.*" By Mr. Edmund Jones.

"*Four Nos. of Quarterly Journal of Geological Society.*" From the Rev. Thomas Wiltshire, M.A., F.G.S.

"*The Quarterly Journal of the Geological Society,* No. 69." From the Geological Society.

A Paper was read,

"On Skulls and Flint Implements, found in the Essex Marshes." By Edward Cresy, Esq. This led to a discussion, in which Prof. Busk, F.G.S., Mr. Mackie, F.G.S., and others took part.

Mr. Evans exhibited some fossils from the railway-works in the Blackfriars-road, and Mr. Bott exhibited fossils from the Woolwich series at Peckham.

Excursion to Hastings.

"Notes on the Excursion." By the Rev. Alfred Deck, M.A., F.G.S.

On Thursday, the 22nd of April, about fifty members of the Association spent some pleasant hours in examining the geology of the Hastings Cliffs. The services of a guide having been secured, attention was first directed to the Castle Hill Rock, showing about

90 feet of nearly pure white friable sandrock, false-bedded, on the top of which was stated to be a bed of shale, containing *Endogenites erosa*, but, owing to the excavations for sand, the shale is now very much cut away.

Near the Chapel and Life-Boat-Station of the Fisherman's Town, is a natural spring in the sandstone, the water coming through a pipe which has within the last few years been driven into the rock. Beneath this conduit is a bed of lignite, continued from behind the Castle Chapel and Pelham Crescent. Close to this spot are the curious caves formed in the sandrock about 200 feet above the beach. Proceeding eastward, the shingle no longer acting as a barrier, nature holds her own, and the weather and sea wear away the rocks. Here the bare cliffs exhibit about 100 feet of sandrock covered with shales and limestone, and more yellow sandrock. The limestone is a thin deposit, and is the bluish-grey building-stone of the neighbourhood. It is the "calciferous grit" of Webster and Mantell, being sand hardened by carbonate of lime. Amongst these shales, *Endogenites* seems to occur in great abundance. Under the white sandrock there are three or four beds of rock containing a quantity of ironstone and small seams of false coal, with shales between; these seem gradually to die away towards the east. Beneath this bedded rock are marls and shales, in which Mr. Beckles and others have discovered fine specimens of ferns. Beneath this again are beds of clay passing down to the beach, one of which is excavated for pipe-clay. Eastward are still lower beds, consisting of hard irony shale; these are soon obscured by the landslip at Ecclesbourne Glen. On the beach some capital specimens of lignite and iron-stone were met with, the latter containing iron in such quantity as formerly to have rendered it worth the working as an ore of that metal. Up the glen are mottled clay beds. The sandstone rocks show excellent examples of weathering, and if these rocks are followed up still further to the eastward, the lignites and clays pass into a large series of purple clay of unknown thickness, with irregular bands of rock, arching upwards at Lee Ness, and forming the whole face at Goldbury Point. They then assume their low form again, and at Cliff End, after a well-marked fault, are succeeded by sands and sandstones, such as are seen at West Hill or Castle Hill. Up in the country these sands seem to be covered by another set of sand and shales, possibly between two and three hundred feet thick, before we get to the Weald Clay.

Along the shore, near Hastings, are large masses of sandstone partly converted, by the lime of *Cyrena* shells, into blue stone or calciferous sandstone, the lime having been segregated at several centres and, thus led to the formation of the nodular blocks now weathered by the sea. In these limestones quantities of casts of bivalve shells belonging to the genera *Cyrena* and *Cyclas* are still evident. There are ripple-marks remaining on slabs from almost all the sandstones, hard or soft, at different heights in the cliff, and natural casts of footprints are sometimes met with. These natural casts occur on the under sides of some of the thin sandstone beds which break away by their weight when undermined. When the footprints were made on clay, the gigantic foot of the Iguanodon did not probably leave so exact an imprint of itself as when made on a harder sandy surface.

The members then proceeded to the Mayor's house for the purpose of examining the large footprint of the Iguanodon which the recent fall of the cliff near the town had brought to light. This beautiful specimen was located in a cave cut out of the white sand-rock, which to the west has come to a lower level. The impression of the foot is very distinct; it has three toes, each of which measures about nine inches long in the tread, with a sort of claw, of perhaps two inches in length. The palm of the foot, where the three toes meet, does not appear to have reached the ground; but the heel has left a small print. From the point of the middle claw to this heel, the impression measures twenty-four inches; and in width it is about twenty inches. The whole of the slab is covered with ripple-lines. Before leaving the cave, the Mayor kindly distributed amongst the party some interesting fragments of *Endogenites erosa* which had been taken from the shales of the East Cliff. This *Endogenites erosa* is either the root of a palm or the rhizome of a fern.

There was no time to inspect Mr. Beckles's fine collection at his house on the Grand Parade at St. Leonards. To this gentleman great credit is due for working out so largely and assiduously the characters, position, and probable relationship of the footprints and the natural casts of tracks found in the Hastings Sand.

Ordinary Meeting, Monday, May 7th, 1862.

Professor Tennant, F.G.S., President, in the Chair.

The following were elected members of the Association:—

Mrs. G. J. C. Duncan; Rev. G. J. C. Duncan; F. O. Feetham, Esq.; John Jones, Esq.; C. J. A. Meijer, Esq.

The following donation was announced:—

Professor Huxley's Address to the Geological Society, 1862. By G. E. Roberts, Esq.

The following papers were read:—

1.—"On Bone-beds, their occurrence in Sedimentary Deposits, and possible Origin." By G. E. Roberts, Esq.

I propose to treat of this subject under two general heads; first, as respects the stratigraphical position, physical character, and organic contents of the deposits so called; and, secondly, as to the probable physical conditions under which they were accumulated.

The following, ranged in order of natural descent, are the deposits which may be designated "bone-beds:"—

1. Eocene bone-bed.
2. Fish-bed, with turtle and crocodile bones, in the Hastings Sand of the Wealden series.
3. Fish-bed at the base of the Inferior Oolite.
4. Fish-bed of the Rhætic series; deposits lying immediately below the zone of *Ammonites planorbis.*
5. Fish-bed at the base of the Mountain-limestone, near its junction with the Upper Old Red Sandstone.
6. Fish-bed in the Passage-shales between the Old Red and the Upper Silurian strata.
7. Crustacean band with some fish-remains, better known as "the Ludlow Bone-bed," occurring in the Downton Sandstone series of the Upper Ludlow rock.

Certain other osseous bands approach very nearly to the character of true fish-beds; of such are thin layers with fish-teeth and fin-spines in the cream-coloured limestones of the Shropshire coal-measures; and the thin beds of blackened shales in the Burdie-House coal, which are in many cases crowded with ichthyic organisms; but neither of these come sufficiently within the natural signification of the term.

The most recent bone-beds at present known are of the Bembridge and other divisions of the Isle of Wight Eocenes. They have been described by Prof. E. Forbes, and more recently by other Government Surveyors. They are contained within thin layers of clays and marl, and are in places charged with ichthyic fragments, chiefly teeth. Next we have the Wealden bone-bed, in the upper part of the Hastings Sand. A good exposure of it may be seen near Cuckfield, from which locality it has received the name of Cuckfield Grit. Dr. Mantell speaks of it as "Tilgate Grit;" this, however, is a misnomer, as it is not known to occur in the Tilgate area. Its organic remains are rolled fragments of bones and teeth of Iguanodons, Turtles, and Crocodiles.

Of a finer mineral composition and somewhat less gritty, is a bone-bed, probably identical in age, at St. Leonards. It nearly reaches the beach at the Church, and is best seen near the steps leading to that edifice; in opening the ground for the laying of these, it was first exposed. The contained fossils appear identical with those of the above-mentioned bed, and comprise *Lepidotus*.

A somewhat similar deposit is seen to occur at Hollington, two miles north of St. Leonards. It may be seen in the sunken ground west of the high road leading from that town to Battle. This is a very "gingerbread-looking" deposit, and appears to possess a most interesting and peculiar fauna. *Hybodus* teeth and the teeth and scales of *Lepidotus* appear to be its characteristic fossils; these, with many fragments of turtle-bone, are regularly arranged throughout a fine-grained yellow sandstone, which has, however, a loose and open appearance from the decomposition of a part of its imbedded life-relics.

I should be glad to hear more of this bone-bed. It has not been my good fortune to visit either of these three Wealden localities; the information I give of them, in connection with the more ancient deposits which I have personally worked, has been kindly furnished me by Mr. Rupert Jones.

The exposures of the Oolite bone-bed are few, and appear to be local. I am not aware that it has been met with beyond the area of the Cotswold Oolites. In that district Mr. Brodie has described it as occurring near Birdlip and Cleeve, in Gloucestershire, and at the near-lying village of Crickley. Its mineral composition is a brownish-grey grit, made up of oval grains cemented by a calcareous paste, and it is seen to contain bones, scales, teeth, and coprolites of *Hybodus*, almost to the exclusion of any other genus. Mr. Nesbit has proved by analysation its highly phosphatic nature.

The Upper Keuper or rather Rhætic bone-bed, to which we come next, has perhaps the most extended area of any. It is seen to occupy the same relative position in the *Avicula contorta* zone of the Upper Trias not only throughout its English area, but also in Ireland, France, Luxembourg, Germany, Tyrol, and the Jura; being in all places a true bone-breccia. Its palæontological contents have given good evidence in the arrangement of the strata, for by the study of its fish-remains at Aust and Axmouth, Sir Philip Egerton was enabled to prove the relation of the *Avicula contorta* series with the Trias, and their consequent separation from the Lias to which they had been at first referred. The chief exposures of this bone-bed are at Garden Cliff, near Westbury-on-Severn, Wainlode Cliff, Combe Hill, near Cheltenham, Bushley, Aust Cliff, long celebrated as the classic exposure of the deposit, where it has a thickness of eight inches, and contains very many fine Ceratodus teeth, Penarth Head, near Cardiff, Uphill, Watchet, Beer Crocomb, near Ilminster, Culverhole, near Axmouth, and other localities in the western counties. It has also been traced northward through Worcestershire into Warwickshire and Staffordshire.

These localities have been more or less carefully worked and mapped; some of the results are given in the "Journal of the Geological Society" for 1860 and 1861, by Dr. Wright, F.G.S., and Mr. C. Moore, F.G.S. Fish-remains and coprolites are the chief organic contents of the bed. But it is chiefly remarkable among deposits of its class for the great quantity of iron which it contains.

In nearly every exposure, the fossils are seen to be fixed in a pyritous cement, but in most this is also cubically crystallised, and forms, as sulphuret of iron, the largest constituent of the bed.

At Westbury Cliff, one of the chief localities, the deposit is a mass of fish-teeth, rolled fragments of bone and coprolites, all metamorphosed alike into black shining bodies of great hardness. Elsewhere though, as at Defford Common, and Dumbleton, in Worcestershire, the fossils are bedded in an arenaceous and ferruginous matrix, and have been imperfectly preserved. The fish genera represented are *Acrodus*, *Nemacanthus*, *Hybodus*, *Ceratodus*, *Gyrolepis*, and *Saurichthys*. Eighteen species have been determined by Agassiz from Aust Cliff, which is so far the metropolis of the deposit, that not more than six have been found in any other site, three only in the St. Cassian equivalent, and nine in the "Knockenbreccie" of Crailsheim, in Wurtemberg.

Mr. C. Moore believes that he recognises this Rhætic bone-bed in the osseous deposit of Linksfield, near Elgin, at first thought to be of the Wealden age, but now regarded as at the base of the Lias. It there contains teeth of *Hybodus*, scales of *Lepidotus*, teeth and vertebræ of *Plesiosaurus*, and some plant-remains.

I have said that co-related deposits of similar age exist on the Continent. This Upper Keuper or Rhætic bone-bed has been described by Oppel and Suess as occurring in Suabia in hard yellow sandstone, bearing the same relative position to underlying red marls and overlying Lower Lias as it does in this country; and in the Bas Rhin, a similar "fish-bed" is seen to occur, though its ichthyic contents are smaller and more fragmentary. The Tabingen bone-bed is probably upon the same horizon, though it differs in palæontological, and therefore geographical conditions, by its possession of Lamellibranchiate shells, *Cardium*, *Mytilus*, and *Lima*. Certain portions of this widely-extended deposit have been described as "cloacinic drift" from the abundance of their fœcal contents, and corresponding scarcity of structural organisms.

A single exposure of a band of osseous drift in the Upper Keuper Sandstones which cap the Red Marls of Worcestershire deserves a passing allusion, though it hardly merits notice as a true bone-bed. It occurs in the Pendock section, and looks very like a layer of old mortar with rolled fragments of fish-bones and a few *Lophodus* teeth set therein.

A very remarkable bone-bed—or rather series of bone-beds—has lately been described by Mr. Charles Wheatley as occurring in "Mesozoic Sandstone," (probably of Rhætic age,) at Phœnixville in Pennsylvania. The strata in which they occur are highly fossiliferous, and the bone-beds are crammed with remains of Thecodont Reptiles and Fishes. One of these layers, six inches in thickness, is a mass of Saurian bones and teeth bedded in Cyprides; "many tons of this osseous drift have been broken up and examined," says Mr. Wheatley, "without any other organic remain being observed." Another of the bone-breccias here is remarkable from the conversion of the Saurian teeth into dolomite; a transmutation so complete that the sulcations of the teeth are preserved; though, singularly enough, the fragments of bone in the bed retain their character unaltered. *Clepsysaurus* and *Composaurus* are the genera of Thecodont Reptiles preserved in these deposits. No remains of Lacertilia occur in English bone-beds; but in the remarkable conglomerate apparently of Muschel-Kalk age which is seen to fill up hollows in the Mountain Limestone, at Redland, near Bristol, two types of this order of Reptilia occur, in *Palæosaurus* and *Thecodontosaurus*. This deposit, however, is not a true bone-bed.

Near the base of the Coal-measures of Nova Scotia a bone-bed naturally comes in. It is well exposed at Horton Bluff, and is there seen to consist chiefly of dermal plates and scales, much broken, of Sauroid fishes. Thin layers of excessively hard limestone accompany it.

The Mountain-limestone bone-bed at the base of the Carboniferous System lies about a hundred feet above the Old Red Sandstone of Clifton and Caldy Island. It ranges from three to five inches in thickness. From the excess of Cestraciont palatal teeth which it contains over other ichthyic remains, some geologists know it as "the palate-bed." Its contained organisms, however, are not confined to fish-fossils, for some of the ordinary Brachiopoda of the system are found in it, together with *Conulariæ*.

The Silurian bone-beds lie among the uppermost layers of the old Palæozoics. The lowest occurs in rocks of Upper Ludlow age, immediately below the liver-coloured deposits known as Downton Sandstones. The higher one lies some fifty feet above its colleague, and seems to belong rather to the Old Red System than to the foregone Silurians. It is generally known as the bone-bed of the Passage-shales.

Rocks, lying in stratigraphical vicinity to a "bone-bed" are invariably highly fossiliferous. It is in these that the most active search should be made for variabilities in species incidental to changes in the condition of the water, and for forms intermediate between, and linking together, past species with future. If such forms are to be sought for anywhere, it must be near the horizons indicated by bone-beds; though I cannot promise that search will be rewarded by the discovery of any "intermediate" going beyond that degree of variability which is the natural property of every true species.

We are all familiar with the graphic descriptions of the older and more important of these osseous breccias, given in the writings of Murchison, Strickland, Phillips, and McCoy, and, more recently, in the instructive memoir of its crustacean contents by Dr. Harley. The description first given of its general appearance may still be quoted as the one nearest the truth, for it occurs in nearly all its exposures, as a "matted mass of bony fragments, some of which are of the mahogany hue, but others of so brilliant a black, that, when first discovered, they conveyed the impression that the bed was a heap of broken beetles."

Dr. Harley also well describes it in some places as "closely resembling the cake from which linseed-oil has been expressed." Many exposures of it are now known in the border-counties of Hereford, Shropshire, Worcestershire, and Gloucestershire. It everywhere maintains the same relative position, and generally occurs between two beds of sandy shales. In the Ludlow district, where it attains its greatest development, it can be most instructively studied in Ludford Lane, and the slopes of Whitcliffe, both localities close to the town; and it is seen in still greatest thickness at Norton, five miles north of Ludlow. A still more northerly exposure of it is in a cutting upon the Severn Valley Railway, close to Linley Station. No scientific notice has yet been published of this locality, but I am glad to hear it has not escaped the notice of my active friend Mr. Randall, of Madeley.

I had the pleasure last autumn of conducting a distinguished palæontologist through the Ludlow district, and we did not, though more especially searching for new and unrecognised facts, forget the classic localities of the old Bone-bed. Indeed, I think I may say, that our most pleasant excursion was to Norton, where its outcrop is marked by peculiar conditions of surface, and where also, its good qualities of hardness and uniformity of texture have been turned to an economical account. This was remarkably the case in a narrow lane leading from the main road to a farm-house. Along this, forming the roadway beneath our feet, and stretching from bank to bank, was a solid pavement of bone-bed; lying in its natural position so nearly horizontal that by inserting our stoutest pick beneath the uppermost layer, and exerting some leverage force, we could raise slabs nearly as large as a London flag-stone! It thus formed a naturally paved cartway to the farm, and had evidently been left as such, by reason of its superior hardness to the shaly sandstones above and below it. I almost wish I could say that we left this *Via Deliziosa* as smooth and unbroken as we found it; but, alas! scientific ardour would not be restrained, and our annexation of four-inch specimens strewed this excellent pathway with its macadamized fragments.

The Herefordshire localities for this "osseous breccia" chiefly lie in or near the Woolhope ellipse, that remarkable upheaved periclinal protrusion of the Upper Silurian series, so well described in 'Siluria' and by Phillips and Strickland. Hagley dome and May Hill are its chief outcrops in that area. It has also been noted as occurring in the immediate neighbourhood of Malvern, at places west of the hills.

If we trace it through the May Hill district southward, we reach its most southernly outcrop (as at present known) at Pyrton Passage, in Gloucestershire, forty-five miles, measuring along a direct line, from its Ludlow exposures, and nearly seventy miles from its most northern station of Linley.

I have next to describe the mineral structure and organic contents of this "osseous and coprolitic drift," as it has been called.

As it is little else than a mass of fossilized remains, united sometimes, as at Hagley, by a calcareous cement, and elsewhere, as in the Malvern district, by an iron-strengthened arenaceous one, I will give its characters by connecting the intermixed conditions. As a typical specimen, we will take one of our four-inch reminiscences of Norton. For at no other locality are its mineral and organic characteristics so well displayed. With a little attention we perceive that its organic contents may be grouped into four divisions; first, and most important by reason both of number and size, are fragments, horizontally divided, of polished spines hollow and thinly walled. Secondly, square and triangular pieces, both irregularly shaped, of shell, of like thickness, and, as far as one may judge, without trying the microscopical tests of Dr. Harley, of like nature to the spines. Thirdly, cusped, horned, serrated, toothed, and smoothly bordered bodies of much tinier dimensions, which, if shape alone guided us, we should decide were teeth, or scales, or plates, or segments.

And, fourthly, solid *bony* fragments, which, though more seldom met with than the objects of the other groups, did at first cause the whole deposit to be called "the Fish-bed." Probably these latter remains *are* of ichthyic origin, but I think we may unhesitatingly refer the preceding ones to the Crustacea.

The spine-fragments were evidently excessively brittle when deposited, so much so that not only have I noticed the longer ones, lying across the line of a shrinkage-crack in the bed, broken by the action of that most gentle of forces, but small square pieces of shelly carapace, similarly situated, are often seen to have been split across and completely divided, without any change in their position. These remains have been slightly arranged by the action of currents, for they lie for the most part with their long axes in one direction.

By what we now know of the animal existences of the Upper Silurian age, it is more than probable that the major part of these organisms are of crustacean origin. Extended research has widened the scheme of palæontological evidence, and we are enabled to compute the value of a special order—and in some cases family—of life at a given period.

Tried by such a standard, it becomes clear to us, that an excess of ichthyic life in an Upper Silurian deposit so accumulated is untenable; while the supposition—even if it was nothing more—that the contents of this "bone-bed" were derived from Phyllopodous Crustacea, finds a natural corroboration in the range and position of that family in the waters of the period. But in the settlement of this question, the microscope has been our best instructor. Dr. Harley's careful investigations prove the crustacean nature of by far the greater contents of the deposit. The conical and teeth-like bodies, together with the small oblong plates (which three kinds of organism, added to the spines afore-named, make up fully four-fifths of the deposit), he refers to small Phyllopods, from their identity of structural character; one group being probably secondary tail-spines of *Ceratiocaris* or an allied genus, and others being apparently detached plates from the limbs or tails of Squilloid or Limuloid Crustacea. To facilitate recognition of these bodies, Dr. Harley has described them in his paper as distinct species of one provisional genus which he terms *Astacoderma*. The identity of the tooth-like bodies contained in the first group with the presumed fish-teeth called Conodonts by Dr. Pander is proved by Dr. Harley, and has since received confirmation from the independent researches of Dr. Volborth.

As regards the actual fish-remains contained in this "bone-bed," their broken, and in most cases rolled and triturated condition, prevents our satisfactory comprehension of their former shapes and life-position. They have been decribed to us as Placoid Fishes of small size, from their fragments of jaws and detached scales, and have received the names of *Plectrodus*, *Sphagodus*, and *Thelodus*. The last genus was made for the reception of small stud-like bodies, believed by Agassiz to be the shagreen scales of a small placoid. These latter forms are by far the most abundant of any ascertained fish-remains; indeed at Gamage Ford, one of the Herefordshire localities, the deposit to the thickness of an inch is composed of little else. Hugh Miller analogically inferred the existence of gigantic ganoids from the dimensions of some fin-spines collected at the Ludlow outcrop; but farther investigation appears to be needed to establish the existence of these monsters. Meanwhile they are placed provisionally in the genus *Onchus*.

At one exposure of this bone-bed in the Hagley Park district, it is extremely micaceous, resembling in this particular its ally of the "passage-shales;" it also contains, in that part of its area, portions of the scute of *Cephalaspis*, and many rolled fragments of *land* plants.

Fragments of the scute of *Pteraspis* have been detected in it at Ludford and elsewhere.

Seed-vessels of those obscure vegetables known as *Lycopodites*, and to which the name of *Pachytheca* has been given, were early noticed by the contributors to the "Silurian system," as occurring in the bed. To the physical value of their evidence I shall presently allude.

In some parts of the area of this deposit, iron forms an important metalliferous admixture, in the form of a phosphate, associated more or less with a bituminous compost.

At its Hagley dome outcrop, a calcareous cement, imperfectly crystalline, unites the bones, exhibiting a chatoyant lustre when the eye catches the light reflected from its cleavage-planes.

The other "bone-bed" of the Upper Silurians, which I before alluded to as lying above the one just described, and almost within the limits of the Old Red system, is in many respects the more remarkable deposit of the two. Its contents are more varied in character, and better preserved. Perhaps no single deposit of old time will better pay for study than this, for it contains evidences of the marine, terrestrial, and probably of fresh-water life of, perhaps, the most interesting period in geological annals. And by contrasting the contained fossils of this deposit with those of the foregoing we obtain a great insight into the geographical relations of the two horizons.

The mineral character of this "bone-bed of the passage-shales," as it is named by my friend, Mr. Lightbody, is nearly identical with the band in the Upper Ludlow; but, as the rule, its contained organisms are more loosely bedded, and the texture of the deposit is less compact. In its fossil contents a notable difference is apparent. Fish-remains are more abundant; and, though *Astacodermata* are plentiful, the long brittle spines of *Ceratiocaris* have nearly disappeared, and in their place we get fragments of the more important genera of *Eurypterus* and *Pterygotus*.

It is worth a passing remark that more than one thin layer in the

Lower Old Red—the deposits next succeeding these passage-shales—may claim the name of "bone-bed," by reason of the abundance of its animal contents. Thus a thin band exposed near the top of the series in the Trimpley quarries is seen by close examination to consist mainly of small triturated fragments of Pteraspis shields, literally a bone-breccia, if it is allowable to call that fish-defence by the name of bone.

Having thus particularized the stratigraphical position and organic contents of these deposits, we come to consider the geographical and physical conditions which led to, and determined their deposition.

Glancing backwards at the stratigraphical position of the "bone-beds" I have described, it will be seen that they occur in zones which bear a certain parallelism to each other in position, each lying near the top of a connected series of deposits. Thus, the place of the two Silurian "bone-beds" is among the top layers of that great and varied series of sedimentary rocks; the uppermost one foreshadowing, both by fauna and mineral admixture, the incoming of the Old Red.

The bone-bed of the Carboniferous System has the appearance, as far as colour and condition of sediment goes, of being a natural summit to the Old Red Sandstone.

The Rhætic bone-beds occur in zones which may truly be called transitional, for they illustrate in a remarkable degree the shifting of currents which seem mainly to have brought about the change from the comparatively barren Triassic deposits, to the more richly stored sediments of Jurassic seas.

The Oolitic bone-bed lies almost in neutral ground between the Liassic series and the pisolitic limestones of the succeeding system.

And the latest bone-bed of Secondary age, that of the Wealden, is situated near the summit of the Hastings Sand, the deposit next but one below the Cretaceous series.

No sudden catastrophe like that mysterious and potent agency which passed through the Old Red Sandstone sea in its Scottish area, and swept it of life, has written its history in a bone-bed; for fish, stricken by pestilence, or killed by mephitic or volcanic vapours, would float and undergo decomposition before they sank, and be partly carried away by tidal action and currents. Local destructions of fishes by such means *have* taken place both in ancient and modern times; but the evidences preserved of such catastrophes are of very different appearances to the organic bands we are studying. The Cromarty ichthyolites, lying each in its limestone coffin are true plague-stricken corpses; while other evidences come to us from the fish-bearing strata of Monte Bolca and the Lebanon, of sea-bottoms paved with the dead. In our own times, sudden destructions of like kind have been noted. Ships have sailed for leagues through immense numbers of floating fishes, and more than once, the herring-trade has been threatened with annihilation from an unlooked-for mortality.

But in less abnormal characters the physical formation of "bone-beds" is written. There is no evidence, either in their own nature, or in deposits of stratigraphical vicinity, of physical cataclasm or organic convulsion. They are to us a record of areas covered with shallow water, swept by light currents, and lying near to a shore. All the conditions they betoken are those of quietude and peace. They tell us, by the number of their entombed remains, of an area well adapted for the enjoyment of animal life; they prove to us the long continuance of those circumstances, and the calm, steady deposition of organic exuviæ beneath tranquil waters; they exhibit to us disintegrating action, though it is but of one animal remain upon another—no pebbly beach churned the relics into powder; and they show us, by the comparative absence of inorganic sediment, that light currents swept through those life-crowded areas, and bore away, to lay beyond their limits, the arenaceous and calcareous grains.

Thus regarding "bone-beds" as the result of conditions peculiarly adapted for the deposition and preservation of organic life, and remembering that under conditions the *most* favourable the number of life relics preserved can bear but a small proportion to the actual population of the area, we shall recognise in these deposits the highest and most complete records of organic life. And hence it is, that to the palæontologist bone-beds mark horizons of peculiar interest and value, as indicating most nearly the actual population in kind—no less than in proximate number—of the age in which they occur. And the more valuable they become in proportion to their nearness to the divisional line "writ in water" which conveniences of study draw between the progressive life-systems of the past, and in proportion to the completeness in which, as in the uppermost Silurian example, a past fauna is retained and a future one reflected.

Such areas of shallow water—archipelagoes with indented coast-lines, specially favouring the migrations of fish by multiplying places for spawn-deposition along the low and sandy shores, and yielding in such conditions most abundantly a supply of appropriate food—specially also fostering the growth of crustacea—deposited the "bone-beds" of our ancient seas. What the philosophic Strickland said of the Keuper one may be equally applied to all, save the one earliest in time, "Generations of fish may have added their remains to the common mass, while, from the clearness of the water, or from the existence of a gentle current which prevented the deposit of mud-particles, scarcely any mineral matter was added to the bottom of the sea." Currents were carrying away sandy grains and depositing them elsewhere, while the organic bodies dropped to the bottom, by virtue of their greater specific gravity, and remained where they fell. Probably these areas of organic deposit owe in some instances a part of their accumulated exuviæ to a mortality among their finny inhabitants, connected specially with changes in the composition of the water, from salt to fresh, and *vice versâ;* but the indications of this do not appear to be strong. No *sudden* physical change has left its impress upon the deposit, and the effects of a gradual, almost imperceptible, transmutation of the element would be correspondingly slight. It seems upon the whole more natural to regard these marked out areas as special feeding-grounds for fish, in which the most favourable conditions for enjoyment of life and the after preservation of its remains were to be found. Doubtless, existing samples of such piscine Walhallas could be discovered by sub-marine research, but this cannot easily be made. We can, however, point to one such feeding-ground, "the Cod-banks" off the coast of Newfoundland; the detritus of which, has been found to yield a great per-centage of fish-remains.

It should also be remembered that fishes in the spawning season would naturally betake themselves to shallow waters and partly sub-aerial sand-banks; no doubt we have all seen, along the course of some river, multitudes of fishes travelling to such a spot; though perhaps no migration in English waters is now upon a large scale: certainly not equal to the passage of fish down an Iceland stream, described by a recent traveller, the numbers of which were so great that when one leapt in sportiveness above the water, it had to remain outside, and flop about on the backs of its more steady companions.

Let us therefore study bone-beds, not as making catastrophic epochas in the progressive chronicle of organic life, but as evidences of transitional change in the contour of the physical surface; changes from wide, though perchance land-locked, seas, washing unbroken coast-lines, to shallower seas covering lesser areas, running into creeks and bays, and having their waters broken by sand-banks and dotted with islands.

Yet, though connected with quiet progress and the slow elaborations of an estuarine surface, "bone-beds" will still hold a distinguished position among the silent exponents of the past, and their teachings will be drawn from a philosophy higher than one which tells only of local derangements of the surface, and periodical destructions of organic life!

2.—"On a Superficial Freshwater Deposit near the Blackfriars-road." By C. Evans, Esq.

For the purpose of obtaining a firm foundation for the arches of the Charing Cross Railway, between London Bridge and Hungerford Market, trenches were sunk to a considerable depth (varying from about 10 to 25 feet) until a bed of gravel was reached, and the excavations were then filled with concrete, on which the brickwork was raised.

To the east of the Blackfriars-road, at a distance of about a quarter of a mile from the present bank of the river, these excavations have passed through various strata, the most constant of which was a bed of sandy clay with vegetable matter and fragments of unrolled flints. Near the bottom of most of the trenches beds of loam and clay were met with containing wood, freshwater and land shells, and insect remains. Mammalian bones have also been found low down in the excavations. These deposits rest upon a bed of sand and gravel with unrolled flints and occasionally rounded flint pebbles.

I have been enabled to form sections of two of the trenches; but I must state that the measurements are merely approximations.

The first section is at the base of the arch passing over William-street. The trench is one of the deepest that has been cut.

Section at William-street:—

1. Made earth about seven feet.

2. Bluish clay with much vegetable matter and a few fresh-water shells, six feet.

3. Earthy peat, five feet.

4. Earthy peat, with patches of sand and woody clay, with numerous shells, and containing large blocks of wood; *Unio* or *Anodon* common; two feet.

5. Shelly sand and clay, with patches of peat, one foot.

6. Earthy peat, with patches of shelly sand and of a light drab-coloured clay. *Neritina fluviatilis* abundant; one foot.

7. Peat, four feet.

8. Gravel, mostly of angular flints, and sand, which was not penetrated.

Total thickness, about twenty-five feet.

The two beds of peat (3 and 7 of the above section) are of very local occurrence, and do not extend as far as the next parallel street to the east. The shell-beds extend rather farther, but appear to thin out to the east, for near the third street, I found the following section (where no shells were found):—

1. Made earth and woody black earth, four feet.

2. Yellow clay, with an irregular surface, one foot.

3. Gravel, of grey and yellow sand with broken and unrolled flints and irregular layers of sand, passing to black earthy gravel, with water, entered to a depth of five feet.

Mr. Meyer has observed a very similar sandy clay, containing *Unio* or *Anodon*, but with much more water, at the excavations for the same railway in the Waterloo-road; and I have observed traces of shelly clay at some drainage-works in the road leading to Southwark-bridge.

In naming the shells I have had the assistance of my friend Mr. Charles Meyer, of Milford, near Godalming (who first brought these deposits to my notice); and the following are the organic remains which we have been able to name from the locality:—

Fresh-water Species.

Limnæa peregra.
„ auricularis.
„ palustris.
„ truncatula.
„ stagnalis.
Succinea putris.
„ Pfeifferi.
Bithinia tentaculata, and operculum.
Physa fontinalis.
„ hypnorum.
Valvata piscinalis.
„ cristata.
Planorbis vortex.
„ marginatus.
„ albus.
„ carinatus.
„ lacustris.
„ spirorbis ?
„ corneus.
„ nautileus.
„ contortus.
Neritina fluviatilis.
Ancylus oblongus.
Cyclas cornea.
Cyclas rivicola.
Pisidium amnicum.
„ other species.
Unio or Anodon.

Land Species.

Helix nemoralis.
„ hispida ?
„ pulchella.
„ rotundata.
„ crystalina.
Zua lubrica.
Pupa.
Carychium minimum.
Clausilia.

Cranium of Goat.
Lower tusk of Wild Boar.
Jaw of Pig.
Teeth, jaw, and other bones of Deer.

Wood of Alder, Birch, Hazel, &c.
Nuts and seed-vessels.

Wing cases of Beetles.

This list gives a total of twenty-seven freshwater and nine land shells. We have found no marine nor brackish water shells.

These shells are all apparently of existing species, and the age of these beds is probably very recent, but it is difficult to assign a precise date.

The mammalian deposits in the valley of the Thames at Maidenhead, Brentford, Richmond, and other places, are in general associated with, and the bones and shells usually occur low down in, a deposit of ochreous gravel composed principally of subangular chalk-flints, named by Mr. Prestwich the Low Level Gravel. This gravel extends in a continuous and uninterrupted sheet from the sea to Maidenhead, a distance of fifty miles, from two or three miles to eight or nine miles wide, and with a thickness of from five to fifteen feet (Jour. Geo. Soc., vol. xii., p. 131). Extinct species of Elephant and Rhinoceros are the most characteristic Mammals of these deposits.

If I am correct in considering the flint-gravel which underlies the Blackfriars deposits as belonging to this low-level-gravel, the Blackfriars shell-beds would be more recent than the beds at Brentford, Grays, &c., and the absence of the remains of the Elephant and the Rhinoceros, and also of the *Cyrena consobrina* tends to support this conclusion.

Mr. Prestwich has described (Jour. Geo. Soc., vol. xi.) a very similar shelly clay at West Hackney, which occurs between two beds of gravel and sand. Little of the clay is now to be seen in this pit; but from the sands below I have recently obtained fine specimens of the Grays *Cyrena*.

Ordinary Meeting, Monday, June 6th, 1862.

Professor Tennant, F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—J. Bathgate, Esq.; W. K. Harrison, Esq.; Jas. Richardson, Esq.; C. P. Serocold, Esq.

The following papers were read:—

1.—"On Mine Surveying and Planning." By M. W. T. Scott, Esq., F.G.S.

2.—"On the Older Parian Formation at Pointe à Pierre, Trinidad." By R. J. L. Guppy, Esq.

The Government geologists, when in Trinidad, gave the name of Older Parian to a series of sandstones and shales extending across the island from east to west, and occupying an extent of about 97 square miles. This formation is only exposed for a short distance on the shores of the Gulf of Paria; but the same formation has been found at Cumana and other places in Venezuela on the continent of South America. The few fossils found in Trinidad and in the same formation at Cumana have led to the belief that the Older Parian was probably of Neocomian age.

During a short visit to Pointe à Pierre, I obtained several fossils from the Older Parian rocks, and these fossils are the subject of the present communication.

The extreme point of the cliff at Pointe à Pierre in the Gulf of Paria is formed of a hard ferruginous sandstone, which is somewhat brittle and coarse in its structure, and contains no fossils. The dip is from 40° to 45° S.

The most conspicuous among the organic remains is a *Trigonia*, considered by Mr. Etheridge to be the same species as that found at Bogotá, and named by D'Orbigny *Trigonia subcrenulata*.* Of this fossil I found one entire specimen and several disunited valves.

Mr. Etheridge notices the entire absence of Cephalopoda in the collections made by the geologists when here, stating that the want of such fossils prevented a comparison with the strata at Bogotá and in other parts of South America.† I have obtained a specimen of *Belemnites* from Pointe à Pierre, so very imperfect and worn, however, that it is difficult to ascertain to what section of that genus of Cephalopoda it belongs. If, however, it belongs, as seems probable, to the sub-section *Acuarii* of Bronn's section *Acœli*, it furnishes additional evidence of the correctness of Mr. Etheridge's determination of the age of the strata exhibited at Pointe à Pierre as Neocomian. The presence of the Belemnite is at once a proof of the Mesozoic age of the Older Parian group; and, as the genus is not found above the Gault, we must consider the Pointe à Pierre deposits as older than the true Chalk.

Numerous fragments of an Oyster, somewhat like *Ostrea carinata* of the Lower Greensand, are found with the *Trigonia*. At the same locality I have found Oysters referable perhaps to two other species. One of these is somewhat like the recent *Ostrea edulis*, and in one of my specimens the markings of the hinge-cartilage are well shown. I

* Geological Survey of Trinidad, p. 163.

† Ibid., and Quarterly Journal of the Geological Society, vol. xvi, page 465.

have also found a single valve of a deeply sulcated species of *Avicula.* This is small, and the sulci, though deep, are not more than five or six in number. It was probably a young shell.

Gasteropoda are represented among the fossils from Pointe à Pierre; but the specimens are generally so imperfect as to render the determination of their relationships difficult. A cast in my possession, upwards of two inches in length from the apex to the peristome, seems to be of a naticoid type. Another cast which has some shelly matter remaining on it may be either a *Trochus* or a *Pleurotomaria*, probably the latter; but the aperture is not perfect enough for identification.

All the fossils I have yet been able to obtain from Pointe à Pierre have been from the beach. They seem to have been washed out from the strata in which they were originally deposited and intermingled with the alluvium of a little hollow in which stand the old works of the Bon Accord Estate. They are consequently much worn; and it is hardly possible to ascertain from what portion of the group they have been derived. Were quarries opened in the adjoining hills this might be decided. The *Trigoniæ* and Oysters are tolerably well preserved as far as their structure goes, but the shells of the Gasteropoda have nearly or entirely disappeared, leaving only casts. The thick and massive character of the shells is worth notice, and it prevails alike in all the specimens in which the shell is preserved.

From what I have said, it will be seen that the evidence of the age of the Older Parian formation is in favour of Mr. Etheridge's view.* Until, however, more fossils can be obtained, and their position in the formation better determined, it will be as well to leave the precise age of the formation an open question. The interest attaching to the point is not confined to Trinidad, as the Older Parian is developed on the main land of South America, at Cumana and other places; and therefore it is to be hoped that on further search more fossils will be discovered.

The following is a list of the fossils found in the Older Parian strata at Cumana and in Trinadad:—

* Geological Survey of Trinidad, p. 162.

Belemnites.	*Cytherea ?* *
Cerithium.	*Cardium.*
Turritella.	*Arca.*
Natica ?	*Avicula.*
Pleurotomaria ?	*Ostrea Couloni.*
Pterocerus.	*Ostrea*, 2 or 3 sp.
Trigonia subcrenulata.	*Echinus.*

On Monday, 16th June, an experimental meeting was held in the rooms of the Association to afford the Members an opportunity of associating together, and of comparing and exchanging specimens with each other.

Mr. C. Evans exhibited a series of London Clay Fossils from the new tunnel of the Chatham and Dover Railway at Sydenham.

Mr. G. E. Roberts exhibited a suite of specimens from the Triasic rocks of Pennsylvania, including the remarkable bone-bed layer and Cypris-shales obtained in the Phœnixville tunnel.

Mr. J. W. Buller exhibited a collection of Fossils from the Inferior Oolite of Dorsetshire.

Mr. J. R. Gregory exhibited a jaw, with teeth, of a young *Elephas antiquus*, from Essex, and a restored model of *Schistopleurus typus* on a scale of 1 inch to a foot.

Mr. J. Pickering exhibited a suite of Fossil Shells from the Main Drainage Cutting through Plumstead Marshes, consisting of Marine, Brackish-water, Fresh-water, and Land Species, accompanied by recent types.

Mr. Charlesworth exhibited some minute Fossils from the Hampshire Tertiaries.

Messrs. Highley, Middleton, Brain, Smith, and Roberts exhibited Microscopes and Microscopical objects of Geological interest.

Mr. G. E. Roberts distributed amongst the Members specimens of Foraminifera from Cuba.

* Not mentioned in the foregoing paper. The specimen is a single valve, 2½ inches long and 2 inches in height, with well-marked concentric lines of growth.

Excursion to Cambridge.

On Friday, June 18, the Members proceeded to Cambridge, under the guidance of the President, Professor Tennant.

On their arrival, the party was received by Mr. Carter, Mr. Lucas Barrett, F.G.S., Mr. Seeley, F.G.S., Professor Babington, F.G.S., and others, and proceeded direct to Barnwell, and examined the extensive excavations now being made in the Upper Greensand and Gault for the purpose of obtaining the phosphatic nodules, which, after due preparation, are extensively used as manure by agriculturists both in England and foreign countries.

A large extent of surface is now worked to obtain these so-called "Coprolites," and the various pits in this locality are said to have brought to light a more extensive and interesting series of fossils than any other locality in the British Isles.

After being thrown out, the "Coprolites" are washed, collected in heaps, removed to another locality, ground in a mill, and then treated with an acid.

The consumption of mineral phosphates, according to a recent estimate by Professor Anderson, of the University of Glasgow, is about as follows:—

	tons.
Cambridge "Coprolites"	40,000
Suffolk "Coprolites"	3,000
And all other mineral phosphates.. ..	5,000
	48,000

which being entirely converted into superphosphates, will yield 72,000; at £5 per ton, value £360,000.

A very interesting description of the peculiar features of the Geology of the district, was given by Mr. Seeley.

The Members availed themselves of the opportunity of obtaining by collection and purchase many valuable and characteristic fossils.

In the course of the walk, Professor Babington drew attention to the remains of an edifice formerly used as the chapel of a Lazar-house, and remarked that these establishments formerly existed in various parts of the country, up to the time of the dissolution of the religious houses, since that time the edifice in question had been used for a variety of purposes, was now unoccupied, and falling fast into decay.

A gravel-pit was next examined, containing land and freshwater shells, and peculiar features in the position of the strata were pointed out by Mr. Seeley.

The Woodwardian Museum with its splendid collection, valuable alike to the palæontologist and the agriculturist, next engaged the attention of the party; the most important objects were commented on by Mr. Seeley and Mr. Tennant, and subsequently, at a second visit, by Professor Miller, who drew attention to a valuable collection of diamonds, and other interesting objects.

Mr. Carter very kindly entertained the Members and their friends at luncheon at his residence, in Petty Cury; several colleges and other places were then visited, and the party returned to town at the time specified.

Ordinary Meeting, Monday, July 7th, 1862.

W. Hislop, Esq., Treasurer, in the Chair.

The following gentlemen were elected members of the Association:—W. Pengelly, Esq., F.G.S.; J. Russell, Esq.; W. Serocold, Esq.; C. H. Tennant, Esq.; S. L. Warring, Esq.

The following donations were announced:—

"*The Quarterly Journal of the Geological Society*, No. 70." From the Society.

"*Volcanos; the Character of their Phenomena, their Share in the Structure and Composition of the Surface of the Globe, &c.*" By G. Poulett Scrope, M.P., F.G.S. From the Author.

"*Gold-mining and Discoveries since* 1851." By J. Arthur Phillips, Esq. From the Author.

"*On the Inferior Oolite and Lias of Northamptonshire and Gloucestershire.*" By the Rev. P. Brodie, F.G.S. From the Author.

"*On the Existence of Purbeck Strata, with remains of Insects and other Fossils, at Swindon.*" By Rev. P. Brodie., F.G.S. From the Author.

"*On the Occurrence of Footsteps of the Cheirotherium in the Upper Keuper in Warwickshire.*" By the Rev. P. Brodie. From the Author.

Fossils from the Inferior Oolite. From J. W. Butler, Esq.

Brachiopoda from the Lower Greensand of Surrey and the Isle of Wight. By C. J. A. Meijer, Esq.

Fossils from the Pleistocene of West Hackney, the Lower Eocene of Charlton, and the Greensand of Dorsetshire. By C. Evans, Esq.

It was announced that the following Societies had agreed to exchange proceedings with the Association:—

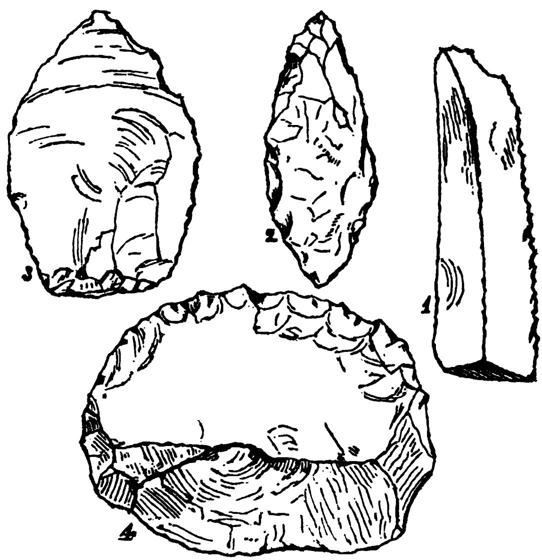
The Royal Institution of Cornwall, the Berwickshire Naturalists' Field-club, the Tyneside Naturalists' Field-club, the Cotswold Naturalists' Field-club, the Royal Cornwall Polytechnic Society, the Glasgow Geological Society, the Manchester Geological Society, the Literary and Philosophical Society of Newcastle-on-Tyne, the Warwickshire Naturalists' Field-club, the Philosophical and Literary Society of Leeds, the Liverpool Geological Society.

The following papers were read:—

1.—"On Diamonds." By Professor Tennant, F.G.S.

2.—"On Ancient Flint Implements, from the fields of Bridlington, Yorkshire." By Syers Cuming, Esq.

All the flints from Bridlington, exhibited this evening by the Rev. Thos. Wiltshire, are evidently split from larger masses, the majority undoubtedly manifesting the handiwork of man—form and design being apparent; rudeness, however, constituting the leading character. The most simple-shaped implements are the long, narrow, triangular spawls, usually, and perhaps correctly, denominated knives, but of which, one has distinct traces of teeth along the convex edge, converting it into a little saw, fig 1. Of more artificial contour than the knives are the arrow and javelin-blades, figs. 2 and 3. These, like all the extremely archaic flint implements, must have been fashioned with few blows, broad conchoidal fractures being seen throughout the examples, whereas the implements of later date were chipped into shape by a succession of strokes, leaving numerous small undulations over the surface and round the edges. Beside the narrow knives and the missile-blades, are broad pieces of sharp flint of less definable purpose, some being conjectured to have been employed as knives or scrapers to be held between the thumb and finger, fig. 4. They may, however, have been set along the edge of a stout staff, like the obsidian blades of the Mexican Miquahuilt. Most of these Bridlington specimens are patinated in a way which only a long series of ages could effect, and which, coupled with their rude fabric, proves them to be of the most remote antiquity.



FLINT IMPLEMENTS FROM BRIDLINGTON, YORKSHIRE.

Excursion to Lewes.

On Wednesday, the 6th of August, the Geologists' Association visited Lewes, for the purpose of examining the Cretaceous strata so largely developed in that neighbourhood. They were conducted by Captain Noble, of Mansfield, to the top of the keep of Lewes Castle, which was kindly thrown open to the Association for the day by the Sussex Archæological Society. From this eminence, a splendid panorama of the county of Sussex is visible; and from this summit of the keep Captain Noble offered the substance of the remarks which follow this account of the day's proceedings. The members were joined by Burwood Godlee, Esq., of Lewes, and by Mr. Martin, so well known from his connection with the late Dr. Mantell, and as the developer of many choice fossils in the British Museum. The Rev. Thos. Wiltshire made some observations as to the fossils which would probably be met with in the subsequent ramble; and the whole party then visited the quarries at Southerham. Subsequently, Mount Caburn was ascended, whence a walk along the top of the Downs brought the party into Lewes again, by way of that wonderful chalk-fault "The Coombe." On the return of the members to Lewes, they were hospitably entertained by Mr. Godlee.

The South Downs, as most persons are aware, consist of that portion of the Sussex range of chalk hills which lies between Eastbourne and Shoreham. They are twenty-six miles long, something like seven wide, and are divided by rivers into four groups. It is with the western division that we now have to deal, or that range comprised between the Adur on the west, and the Ouse on the east. Its southern slope is bounded by the English Channel, except towards the south-west, where a flat district, extending from near Brighton to Shoreham Harbour, separates it from the sea-shore. The ridge bounding it on the north presents a steep escarpment to the Weald, and is the highest land in Sussex; Ditchling Beacon, the centre of the line, being 864 feet above the level of the sea. Lewes is situated on the eastern extremity of this range. The Chalk Downs form an amphitheatre of hills to the east and west of the town, but the northern and southern slopes are skirted by the "Levels," a set of fluvio-marine deposits of relatively modern origin, of which we shall presently speak. The Cliff Hills, constituting another division of the South Downs, are a small, insulated group, separated from the central and western chains by the intervention of Lewes Levels. The edge of this range runs parallel with the road from Southerham to Glynd and Glyndbourne, passes near Ringmer in its western course, and terminates at Old Malling, near the banks of the Ouse. The south-eastern angles formed by Mount Caburn and the western escarpment are deeply indented by a steep and most remarkable valley, "The Coombe." Lewes Levels, which we have referred to as intervening between the western and central divisions of the South Downs, is a marshy alluvial plain, through which the Ouse flows to the English Channel. Tradition and local nomenclature would lead us to infer that within the historical period these levels were covered either by an arm of the sea or an inland marine lake, which extended up the country far beyond the town of Lewes; the site of its existing suburb, "The Cliffe," being buried beneath the waters. Numerous sinkings through the soil have shown these alluvial deposits to consist of:—

1. Bog-earth and peat, with leaves of hazel, oak, and birch, enclosing large trunks of trees. This bed is almost five feet thick.

2. Blue clay, with fresh-water shells of the same species as those now inhabiting the Ouse and neighbouring ditches, and the indusiæ of caddis-worms. Bones of horses and deer have been found at the bottom of this bed.

3. Clay containing fresh-water shells with an intermixture of existing marine species.

4. Blue clay enclosing marine shells, without any admixture of fluviatile species. The skull of a narwhal, and one of a porpoise, have been obtained from this deposit. These last three beds combined vary from three to twenty-five or thirty feet in thickness. Finally, there is a bed of pipe-clay, evidently derived from the subjacent chalk.

The chief points of interest were the Cliff Hills, the visit to the quarries in which formed the main business of the day. These Cliff Hills are separated from the central and western chains of the South Downs by the River Ouse. They are situated to the east of Lewes itself, the line of quarries worked in them stretching away in a south-easterly direction. On leaving "The Cliffe" for Southerham and Glynde, we pass a large quarry which is now no longer worked, exhibiting a section of the Upper Chalk some two hundred feet thick. Dr. Mantell states that a canal or dike, filled with chocolate-coloured clay, sand, and ochre, was to be seen in this quarry; there are now, however, no visible traces of it. The strata in this pit are horizontal. Proceeding onwards, and skirting the Ouse, we arrive at a quarry in the Lower Chalk, remarkable for the inclination and direction of its beds. They are inclined *obliquely* towards the north, at an angle of from 20° to 30°, their planes being depressed towards the west. From this pit several interesting and characteristic fossils were obtained, consisting of coprolites, portions of Fish, Pectens Terebratulæ, Ventriculites, &c. Another pit in the direction of Glynd yielded a fine specimen of *Pecten Beaveri*, a very characteristic fossil of the Lewes chalk, claws and portions of the carapace of the *Enoploclytia Leachii*, and a large Ammonite.

Ordinary Meeting, Monday, September, 1st, 1862.

Professor Tennant, F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—G. Wallick, M.D.; James Wadison, Esq.; Robert Dakin, Esq.; J. H. Clement, Esq., F.G.S.; Burwood Godlee, Esq.; T. M. Mackay, Esq.

The following donations were announced:—

A series of Fossils from the Brick-earth of the Nar, Norfolk. By C. B. Rose, Esq., F.G.S.

Fossils from the London Clay at the Maindrainage-works, Hampstead. By C. Evans, Esq.

"*Quarterly Journal of the Geological Society*, No. 71." From the Society.

"*On the Flint Implements of Yorkshire.*" By the Rev. Thomas Wiltshire, M.A., F.G.S.

The following paper was read:—

"On the International Exhibition." By the President.

Visit to the Main Drainage Works.

On Saturday, the 18th October, the members and their friends, accompanied by Professor Tennant and the Rev. Thos. Wiltshire, M.A., F.G.S., and under the guidance of Mr. Lovick, assembled at Old Ford, at the junction of the high and middle level sewers, in the Penstock Chamber.

It was explained that these sewers were brought to this point partly for the purpose of securing a ready outlet into the River Lea for the discharge of the waters collected from excessive storms, by means of weirs, so adjusted as to preserve the ordinary channels from undue hydraulic pressure, and which passed the accumulated waters into that river through duplicate lines, which had been formed at a lower level.

The arrangement of the various flaps and penstocks, in connection with these works, was examined, and it was shown how, by various mechanical appliances, the water could be diverted from or into either sewer, or through the overflow-system beneath.

The works from this point to Abbey Mills were next inspected. These consist of two parallel sewers, passing over the several branches of the River Lea, one for the high level, the other for the middle level, each channel being 9 feet high and formed above the level of the marshes upon concrete foundations, surrounded with concrete, and surmounted by an earthen embankment.

At Abbey Mills there is a third and similar parallel sewer formed for the purpose of taking the low level drainage, which will be pumped up into it at that place; the three streams—high level, middle level, and low level—running from thence, side by side, to an outfall in the Thames at Barking Creek.

The general features of the system were explained, and the directions of the intercepting sewers pointed out upon a map of the district.

The scheme of the main drainage of London is for the purpose of intercepting or cutting off from the Thames all the sewage that now passes into it, through innumerable channels, within metropolitan limits, and discharging it, through a few main drains, into the river at distant points, and at such periods of the tide as will effectually prevent its return.

With this view, and partly to take advantage of the natural (or unaided) method of discharge, the metropolis has been divided into areas of two kinds. The first includes all that can be drained to the distant outfall by gravity alone; the other, all that requires artificial aid to drain it, and the discharge from which, in practice, will have to be collected at depths much below the level of the natural outfall, and from thence pumped up into the higher or gravitating channels.

The intercepting sewers are adopted to discharge the sewage of London, prospectively considered, and its equivalent of rain-water.

The total area drained is about 117 square miles; its estimated prospective population, three millions and a half; the length of the new sewers about 82½ miles, in sizes varying from 4 to 12 feet in height and width; and the cost is estimated at £3,000,000.

The works that are either completed or under contract extend to 50 miles in length, and their probable cost is £2,000,000.

The whole culminates at Barking Creek and Halfway Reach, or 12 and 14 miles respectively below London Bridge, in two reservoirs of a total capacity of 13,000,000 cubic feet, from which the sewage is finally sent into the river during the first 2½ hours of the ebb tide.

Visit to the International Exhibition.

On Tuesday, 23rd inst., the Committee of the Geologists' Association met the Members and their friends at the International Exhibition, with a view to the examination of some of the more interesting geological and mineralogical specimens from North Wales, New Brunswick, the Ionian Islands, Brazil, Russia, Sweden and Norway, Austria, and the Zollverein.

The proceedings commenced by Mr. J. H. Clement describing the specimens of gold and gold-ores exhibited by the Vigra and Clogau Company and by Mr. Readwin. He said:—I beg to call your attention particularly to Mr. Readwin's specimens. The great merit of these is, that, taken in a geological point of view, they prove that the Lower Silurian formation on the north side of the River Mawddach contains quartz-lodes which contain, besides other minerals, gold in appreciable quantities, and not alone in one measured spot, as the case exhibited by the Vigra and Clogau Company represents, but in a length of some 18 miles; and, from all I was able to prove during a residence of a year and a half, by constant assaying by fire, and analysing by chemical means, I proved these facts without the visible signs now displayed to you. It was several months before I saw visible gold in 1845 and 1846. I now present to your view the first stone obtained with visible gold in it which was found in that country: it is from the mine of Cwmheisian, thrown out by some miners; the taker of the bargain to excavate the level in the mine was by name William Owen: this was in 1845. The assaying of the ores under Mr. Harvey began in 1842, but nothing satisfactory came of these assays, which proved the existence of gold, until some considerable quantities of gold was found by fire-assays of ores and stones from the Cwmheisian Mine, near the Falls of Rhaider Mawddach and Pisyll Cain; after which Mr. Arthur Dean, civil and mining engineer, whom Mr. Harvey employed to sell the mine for him, put together all the facts then known of the existence of gold up to the time, and read a paper thereon before the British Association in 1844, attempting to show that a regular system of gold-veins existed in the Snowdonian district, as he called the Dolgelly district. In 1845 Mr. James Harvey consulted me at his office in Old Broad-street, London, as to the fact of gold being present in some parcels of ores he then showed me. This led, as I could not see gold in those ores exhibited to me in his office, to my going down to Dolgelly, and personally visiting his mines and those he had sold to a Mr. Bruin for £15,000. I inspected, with Mr. James Harvey, all the mines and places where lodes cropped out to the surface, from a place two miles west of Vigra Copper-mine, known as Caegwian Bulchcoch; Vigra Copper-mine (deep, and flooded at the time); Clogau Copper-mine; and all the lodes visible north and south of Clogau Copper-mine, which included a hole on the top of the hill, under which is now worked the St. David's gold-lode, belonging to the Vigra and Clogau Copper-mining Company, in Clogau Mountain; making our exit out of the mountain near Borthonog, at the same date pointing out where an adit should commence from. All the spots visited I considered on that day good for copper, so far as concerned Vigra and Clogau, but as surface-holes I could not decide upon their value until the samples taken should be assayed: I could say nothing more than that they were places with good indications of mineral wealth for copper, any gold in them would follow the copper in the dressing, and subsequently be found. I then visited Tyddyngruladus, a silver-lead-mine, and declared it at once a good lead-mine; that as to silver or gold, it must be decided by fire-assay. We then visited Cwmheisian West Mine, which appeared, from all I heard of its produce, to have been a good lead-mine, but abandoned in 1844, for the sake of the East Cwmheisian gold-mine. Here, again, I could find no visible gold in the ores or stones of the mine-stuff, but succeeded in finding a show of gold-dust in some wastes from an endless buddle, the invention of Messrs. Brunton, who had erected other machines at this mine to separate gold by means of its specific gravity, after fine grinding, all of which failed. I was subsequently appointed by Mr. Bruin to systematise the operations; consequently all future operations at the Cwmheisian Mines, and all others purchased of Mr. Harvey, came under my control in 1845. I set to work the Cwmheisian Mine proper, Caegwernog, and Berthlwydd, and took care personally to regularly assay the ores that were extracted, and found at Cwmheisian the ores contained over 1 oz. per ton. The same with those at the Berthlwydd. The lode at Caegwernog became so small that that mine was stopped, and subsequently all the other mines, from want of funds on Mr. Bruin's part. As I have already said, in the Lower Silurian formation there the quartz-lodes with mineral substances in them are now proved to have gold in them for a distance of some eighteen miles in length by two-and-a-half to three miles in width, in which I expect there are six parallel lodes, all of which contain gold; it must not be understood that I mean to say that all along every lode there will be gold in paying quantities, or in any degree equalling the present or past produce of the St. David's lode in the Vigra and Clogau mining sett; but there will be the same chance of finding points quite as rich, I have no doubt; and I believe that such points will be indicated by the quantities of certain mineral substances in the lodes and encasing rocks, which I consider to be nickel, black oxide of iron, and manganese. In some cases sulphide of lead will be found rich in gold, as at Moel Yspry, where I discovered it first in 1846, in combination with silver. All, or nearly all, the copper-ore of the district, when found in lodes running through the Lower Silurian formation, contains gold. In the Cambrian sandstone there are some strong lodes, which are parallel to the gold-lodes; but in them hitherto I have never found gold; but I am free to confess that Messrs. Johnson and Matthey, of Hatton-garden, have found as much as 12 grs. per ton, which has caused me some surprise. Subsequent assays have not, I understand, given more than a trace; this proves that gold is somehow or other there, and I consider there must be a cause for only a small quantity being present. I suspect that Messrs. Johnson and Matthey's assay was from a lode very much in a portion of both formations; or a portion of the Lower Silurian formation may have become enveloped in the Cambrian sandstone during some convulsion of these Dolgelly hills. There are several eruptive rocks in the Lower Silurian formation; some are siliceous greenstones, some are felspathic, some are magnetic. Such, if they are near any lode, have, no doubt, added their influence in the deposits of gold (as an instance of such power, view the depositing of gold, silver, or copper in the western annexe by magnetic influence) in the lodes near them, as well as causing large deposits of bisulphide of copper and other sulphides, such as of iron and zinc; also galena, which is a sulphide of lead. Such galena as is in the east and west lodes of the Dolgelly district, that hold gold, is accompanied by antimony, as may be observed at Moel Yspri. Further east, at West Cwmheisian, where the lodes are found running through, or near, a basaltic formation, in the Lower Silurian formation, the sulphide of lead is purer, and only contains sulphur, silver, and gold. In this mine there is a band of sulphide of iron averaging three to six inches wide, and containing metallic gold, which becomes visible on dissolving out the sulphur by acid. By roasting such ore the gold does not in every case become visible after roasting and washing, which is a curious fact, but one which can be chemically explained. In conclusion, I can only say I am happy to have had this opportunity of pointing out to you the known facts of the discovery of gold in Wales, its site, and the formation that seems all over the world to be favourable to its production; and although, if looked on as a picture, the Dolgelly gold-field may have a rather different appearance from other countries, I maintain that the gold-rocks are all of the same era, which may be claimed to be of the Lower Silurian period; they are chemically composed of the same substances, and developed under the same influences; but in other countries they are more gigantic in form, and more extensive in regard to territory, On a future occasion I hope to bring the mining for, and metallurgy of, gold before you.

The Rev. D. Honeyman remarked that it was often considered in

England that the whole of the British Provinces in North America formed but one district, but this was not the case, the Upper and the Lower Provinces being distinct; New Brunswick, Nova Scotia, Prince Edward's Island, and Newfoundland forming the Lower Provinces, and the Canadas the Upper Provinces. The forests were one of the chief resources of all of them; and with regard to the colony in whose court they now were, he could tell them that they had pines, cedars, and other trees, which would have enabled a timber trophy to have been formed which would have rivalled that of the neighbouring provinces; and he trusted that at another International Exhibition, in 1872, the Lower Provinces would make a far better show. They may see around them some very handsome native costumes, although the aborigines were fast disappearing, both in New Brunswick, Prince Edward's Island, and Nova Scotia. The great natural resources were the quarries; and the St. John's River, which was navigable for a great extent, offered many facilities for transport. The geology of New Brunswick was much the same as that of Newfoundland. They had the Lower Silurian, which was, probably, auriferous in New Brunswick as well as in Nova Scotia, the Middle Silurian, the Mountain-limestone, and the Carboniferous or Coal formation. These bore much the same characteristics as the corresponding formations in this country; they had the same Trilobite in the Mountain-limestone, for example, and so on. With regard to building-stones, they had granite, syenite, and gypsum, or plaster-of-Paris stone. He might here observe that in England this latter material was of Triassic formation, whilst in Nova Scotia and New Brunswick it occurred in the Lower Carboniferous. Many errors had crept in amongst the earlier geologists in consequence of this, and he believed they were first set right by Sir Charles Lyell. They had hematite iron-ores of great value in the province; but, perhaps, the most interesting mineral was the Albert coal, or Albertite, a specimen of which he would pass round for their inspection; it was so called from being found in Albert County. Some supposed Albertite to be of Devonian age: some, and amongst these Dr. Percy, Mr. Hay, and Dr. Jackson, consider it to be true coal; whilst Dr. Taylor, the author of "Statistics of Coal," regarded it as an asphalt. It was first discovered by

Dr. Abraham Gesner, who considered it to be an excellent material for the manufacture of gas (upon analysis Albertite gives—carbon, 85·90; hydrogen, 9·00; nitrogen, 2·97; sulphur, a trace; oxygen 2·03; ash, 0·10 = 100·00); but as the gas-company had a monopoly for making gas from coal, a law-suit was the result, it being disputed whether it was or was not coal. The fact was, that in composition it approaches very nearly to the jet of Whitby. From this Albertite they extracted an oil which was called Albertine, and which had all the properties of paraffin-oil.

The company then proceeded to the Ionian Islands department, where Professor Tennant described the various specimens exhibited, and explained the geological formation of the islands. Alluding to some specimens of breccia found in caves, he remarked that in the hands of geologists they would teach much; they were of sulphate of lime, or alabaster, which was used extensively for making plaster-of-Paris, and had been used from the time of Nineveh for the making of cement. Dr. Kalvo had promised to describe the specimens in this court, and he could only regret that indisposition had prevented his attendance.

Upon reaching the Brazilian court, Mr. Clement, at the request of Mr. Oliveira, explained the heavier specimens. He remarked that the whole formation met with there was the Lower Silurian; but it was upon a very exaggerated scale, the formation being similar to that which he had referred them to in speaking of the Welsh gold-formation.

The very attractive collection exhibited from Russia in the nave, showing the application of jasper, chalcedony, garnets, lapis lazuli, jade, malachite, &c., to ornamental purposes, was next described by Mr. James Rushforth, the most interesting article being the casket with minerals—ornaments representing various fruits. The grapes are of nephrite, the ripe gooseberries of cornelian, the green gooseberries of quartz, the barberries of coral, and the raspberries of "rhodonotine," which appears to us to be a kind of manganese spar. The whole collection forms part of the cabinet of the Emperor. The company then visited the Norway and Sweden courts, where Professor Tennant briefly described some iron-pyrites, phosphate of lime, specimens of silver, granites, porphyries, serpentines, &c., and pointed out a fine specimen of Silurian limestone, with sections of Orthoceras in it.

The visit to the Zollverein departments was undoubtedly the most interesting portion of the day's proceedings; the collection being admirably and systematically arranged, and well understood by the gentleman entrusted with it, Dr. Hermann Wedding, who spared no effort to make the inspection of it interesting. He commenced by describing the very excellent geological map (prepared by Mr. Von Dechen, of Bonn) of Westphalia and the northern part of Rhenish Prussia. The whole of the central portion of the district was of Lower Devonian age, and the "Lenne-Schiefer," or Middle Devonian, went on even to the other side of the Rhine; being only intersected by the Tertiary just in the valley of that river. The Coblentz sandstone was interesting from the value of its spathose-iron, galena, and zinc-ores. The coal went far under the Cretaceous beds shown in the upper portion of the map, and the coal-basin of the Rivers Inde and Worm, were interesting by their difference. The Tertiary formations of the district contain much lignite. He would next direct their attention to the map of the coal-basin of the Ruhr, from which they would see how the coal extended, as he had said, not only to the Rhine, but on the other side of it. The next plan was important, as showing where the new ironstone-beds in the Teutoburger-Wald Mountains were found; and next was the plan of sections of the coal-fields near Aix-la-chapelle. He might tell them that under the Tertiary the coal-beds were bituminous near the surface, and anthracitic lower down. At the junction of the coal-measures and limestone, important deposits of zinc-ore were found. From the special section of the Westphalian coal-fields, they would see that the coal-formation extended under the Cretaceous. The seams run in saddles, and are very numerous; but the greatest portion of the whole formation being below the Cretaceous, it is necessary that all the pits should be well tubbed, to avoid inconvenience from the water. Unfortunately, there are only small beds of ironstone, so that in England we had the advantage near the corresponding formations. The Lobejun coal-field was especially interesting, from the extraordinarily contorted form in which the seams occurred. The

Stafsfurt salt-springs were formerly worked by pumping simply; but within the last ten years a pit had been sunk through the Bunter beds, and the rock-salt more than 100 feet thick was met with. Recently, a pit was sunk at Erfurt with equal success, but this was in the true Trias. The last plan which he would shew them was a chromographic representation of the yield and vend of coal in Prussia. The different colours represented the different coals; the colours being all to scale, the amount of each coal sent to each place could be at once ascertained. They would remark the large quantity of English coal which went to Berlin; nearly the whole being, of course, from Durham and Newcastle, as there was then water-carriage only. They would see, in the same manner, the distribution of the coals of Westphalia, Saarbrück, and Upper Silesia. Since 1861 much Westphalian coal had found its way to Berlin, and he trusted the amount sent there would continue to increase. In Silesia they had the largest coal-measures in Europe; the beds there are thick and flat, and nearly like those of South Staffordshire. There is some little difficulty, however, in fully developing them, owing to the Prussian portion being between parts of Russia and Austria, and for the present the duties are too high. The Muschelkalk beds are important for the deposits of zinc. He next directed attention to the Riesengebirge, which, he reminded them, are 5,000 feet high, composed principally of crystalline slate and granite, and to the copper-bed in the Zechstein of Prussian Saxony, where the Kupferschiefer, or copper-slate, is worked by the Mansfeldt Company. Dr. Wedding then proceeded to describe the ores and minerals. On the Inde the coals had long been worked by the Eschweiler Company. One particular feature to which he would direct their attention, was the use of glass sieves for washing the coal; it was found that the sulphuric acid in the coals had a powerful action on the wire, so they had substituted glass, which they found to answer admirably. In the Ruhr basin they raised an iron-ore which was found, from the large amount of phosphorus, sometimes from 12 to 20 per cent., which it contained, to be quite unfit for making iron; attention was, therefore, directed to the phosphorus, and it was discovered that, by calcining and decomposing it with acid, it could be converted into a valuable manure. He would next call their attention to the lime-cokes, or coke obtained from small-coal and lime, the object of which was, to enable iron-ores to be smelted without other flux. Just above them were some interesting specimens of brown-coal, which they would see was of three distinct characters—the earthy, the woody, and the lamellar; the latter was very rich in paraffin, and the woody yielded an excellent charcoal. The spathose-iron-ores would next claim their attention; they were very interesting, as being the ore from which the well-known "spiegeleisen" was obtained; the spiegeleisen having recently been imported into England for the manufacture of steel. They had blackband-ores, but they were not very large or rich; and claybands also, which gave iron of excellent quality. The lead-ores were mostly found in the same strata as the spathose-iron-ores; and he would especially direct their attention to the specimens of argentiferous galena. There was also a good specimen from the Bunter beds; they could see distinctly the little grains of galena in the sandstone; there is a seam 120 feet thick of the same kind. They had many zinc-ores, both as blende and calamine, and the various processes for separating the metal were represented. Amongst the copper-ore, perhaps the most interesting specimen was the "fahlerz," which was rich in silver; the poor ores containing copper, blende, and galena; all are separated with success. Some ores are treated with sulphuric and the poorer with hydrochloric acid. The process has been long in use, and it is found that ore containing only one-half per cent. of copper leaves a good profit. The manganese-ores, as they would see, were well worthy of attention; and the building-stones, slates, and marbles, represented by the specimens exhibited, were found in large quantities. Upper Silesia had some excellent calamine, there being, as they would see, two distinct kinds—the red and the white; the latter was the best, the red being sometimes too much mixed with iron. To turn to the metallurgical products, they would find some exceedingly fine specimens of "spiegeleisen," some of which was the more interesting, being manufactured with coke instead of charcoal, and they should also examine the spring of cast-iron direct from the blast-furnace. The lead, zinc, and iron from the Concordia Works, near Eschweiler, were worthy of observation, because the metals were all together in the ore, and were obtained with a large profit. With regard to the "spiegeleisen," he should tell them that it was usually found that the larger the quantity of manganese contained the larger were the facets of the crystals obtained. The bar of selenium was probably the largest ever exhibited; it was obtained from the copper-smoke, a sample of which was also exhibited. The nickel and cobalt exhibited were principally from Nassau and Westphalia, and they had also some fine specimens of cadmium in the metallic state. The next case of which he would ask their inspection was one containing some small samples of gold. In former times there were arsenic-works in Silesia, and in the residua from the arsenic-manufacture Plattner discovered gold, and the gold is still extracted. The residua are first treated with chlorine, and the gold extracted. The gold was not obtained in large quantities, but it was interesting, as the ring used at the marriage of the Princess Royal and the Prince of Prussia was made of it. The copper-products from the Mansfeldt works were very interesting; and even to the works themselves much interest attached, from the fact that the discoveries both of Augustin and Ziervogel were made there. The doctor concluded his address by describing the very beautiful specimens of paraffin exhibited by Dr. Bernhard Hübner, and which are so treated as to melt at various temperatures, according to the purposes for which they are to be used.

The thanks of the Association were given to Dr. Wedding for his interesting remarks.

Ordinary Meeting, Monday, November 3rd, 1862.

Professor Tennant, F.G.S., President in the Chair.

The following gentlemen were elected members of the Association:—G. Dibley, Esq.; H. Belcher, Esq.; H. P. Wyatt, Esq.; W. P. Rickards; W. R. Williams, Esq.

The following donations were announced:—

Presented by the President.

"*Lectures on the Strata near Cambridge.*" By Professor Sedgwick.

"*Account of the Colony of South Australia.*"

"*Descriptive Catalogue of Rock-specimens in Museum of Economic Geology.*"

"*Descriptive Catalogue of the Economic Minerals of Canada in the International Exhibition.*"

"*Nova Scotia and her Resources.*"

"*Annual Report of the Plymouth Institution,* for 1861." Presented by the Institution."

The following paper was read:—

"On Coal-Plants." By Professor Morris, F.G.S.

Among the more important and most valuable researches of the geologist and palæontologist, probably there are none more interesting than the enquiry into the early condition of the ancient physical geography of the globe, as derived from the study of organic remains. Replete as the sedimentary strata are with the remains of ancient life, it is only when we study them in connection with the habits and distribution of existing allied forms, that we can derive information of any practical importance. As the marine and fresh-water shells imbedded in the different rocks reveal to us the subaqueous conditions under which they were accumulated, so also may the remains of plants inform us of the ancient terrestrial conditions, and the successive changes which the earth's surface has undergone.

The accompanying notice on the vegetation of the Coal-period is merely intended as a summary of the subject, and will be considered as briefly as possible under the following heads:—

1stly, the nature of fossil plants generally; 2ndly, the history of the coal-plants in particular; 3rdly, their mode of occurrence, condition, and state of preservation; 4thly, their natural history and relation to existing vegetation; 5thly, their numerical proportion and geographical distribution; and, sixthly, the consideration, perhaps, of general inferences deducible from the study of them.

Fragments of plants are distributed through most of the fossiliferous strata. Well-preserved specimens are found in many of the sedimentary rocks, but they are irregularly distributed, being but scantily represented in some deposits, and occurring in great abundance in others—sometimes so as to form thick beds of coal. Those met with in deposits near the surface, such for example as the peat-bogs and turbaries, which consist of the latest accumulation of vegetable matter, contain only plants or trees identical with existing forms; as, however, we recede in time, greater differences become observable, and living generic types are only found. Thus it is that in the Pliocene strata the plants are nearly all of existing species; in the Miocene, some new; and in the Eocene, more new species. The brown-coal of Europe, of Lower Miocene or Upper Eocene age, represented in this country by the Bovey coal of Devon, contains some existing genera and a few existing species; the Lower Eocene deposits, *i.e.*, the London Clay and Woolwich beds, contain a tolerably abundant flora, chiefly, however, consisting of fossil fruits, but the forms are markedly distinct from those of the European flora, and present affinities to tropical and extra-tropical types; thus we have *Nipadites* allied to the Nipa of the Moluccas; *Petrophyloides*, which were proteaceous plants with cone-like fruits, like those found in New Holland and South Africa; and also the genera, *Hightea*, *Wetherellia*, *Cucumites*, &c., besides fragments of Palms and Conifers. The Cretaceous rocks of England contain but few plant-remains; these belong to the *Fuci*, *Coniferæ*, and *Cycadaceæ*. But the same rocks in other parts of Europe contain an abundant flora, including many dicotyledonous plants, as in the vicinity of Aix la Chapelle, in Germany, and in Russia. The plants of the Wealden are more numerous, comprising Palms, Cycads, Conifers, and Ferns; and, although in this country only scantily distributed, in other districts, as in Hanover, where thick beds of coal occur, the vegetation of this period must have been more luxuriant. Some divisions of the Oolitic rocks here and there abound in plants—the Coniferous and Cycad trunks above the Portland beds are well known; but the Lower Oolite of Oxfordshire, Yorkshire, and Sutherlandshire contain many species of Ferns, Cycads, and some Conifers, which in the two last-mentioned districts have probably contributed to form the Moorland and Brora coal. The Lias, both in this country and in Europe, generally has vegetable remains similar to those of the Oolite, but differing in species; in this country, they do not form coal, though in some localities, this flora must have been very luxuriant, for thick beds of coal of this age are found in Hungary, Austria, the Caucasus, and at Richmond, in Virginia. The Trias has its Cycads, Conifers, and some Ferns; the New Red Sandstone, for example, having a somewhat similar flora to the Lias, with some *Coniferæ*, of which the *Voltzia* is the principal. The Permian formation of England, Germany, and Russia contains remains of about one hundred and eighty species; the plants, however, of this system are more allied to Palæozoic than Mesozoic forms. One division of the Palæozoic rocks—that which in this country at least contains the most numerous remains of an extinct vegetation and the thickest beds of coal, has been aptly termed the Carboniferous formation, and may be said strictly to represent the Palæozoic flora; not, however, that we are here presented with the first traces of vegetation or even of a terrestrial one, as formerly supposed, for the Devonian rocks of Ireland contain fossil Ferns, *Adiantites*, and stems of *Cyclostigma*, related to the *Lepidodendron* and Calamite, which have been well described by Professor Haughton.* From rocks of similar age in New Brunswick, Maine, and Canada East, Dr. Dawson has described more than fifty species belonging to the genera, *Calamites, Dadoxylon, Aploxylon, Sigillaria, Asterophyllites, Lepidodendron, Lepidostrobus, Lycopodites, Psilophyton, Selaginites, Cordaites, Pycnophyllum, Cyclopteris (Jacksoni), Sphenopteris*, and *Neuropteris*. Of these forms, one, *Calamites transitionis*, is found in Europe, and another, *Cyclopteris Jacksoni*, may be compared with the *Cyclopteris hibernicus* from Ireland. Professor Goeppert, referring to Germany and Silesia, enumerates fifty species of land-plants, and seven others obtained from similar deposits; but, while there is an equal generic identity between the Devonian plants of Europe and America, there appears to be a greater specific difference than is noticed when the Carboniferous flora of the two countries are compared.† Below these are the Silurian and Cambrian rocks which present us with few remains of vegetable life, unless indeed we include the coal-

* Journal Geological Society, Dublin.

† American Journal of Science, vol. xxviii, p. 279.

field of Oporto, referred by Sharp to Silurian age, but certainly containing Carboniferous fossils. The plants of Silurian age are chiefly fucoid-like plants or *Algæ*, and spore-cases of Lycopods.* It will thus be seen that the study of fossil plants leads to the same results as the study of extinct animals, the farther we recede in time the greater is the difference, as compared with existing forms. Remains of fossil plants attracted the attention of the earlier naturalists, who gave figures and descriptions of them under the name of Phytolithes, Lithonylites, &c. Of the works upon this subject, it may be useful to notice the more important and accessible.

Of the early publications in which coal-plants were referred to are those by Gesner, in 1561; Cordus in 1651; and by Major in 1664. Among the more important works on this subject in the eighteenth century were those of Petiver, in 1702; Scheuchzer, (Herbarium Diluvianum,) 1709; Büttner, in 1710; Wolfart, in 1713; Valentin, in 1714; Mylius, in 1718; Volkmann, in 1720; Swedenborg, in 1722; Bruckmann, in 1727; Schülze, in 1755; Walch, in 1773; Schröter, in 1784; and Suckow, in the same year. At the commencement of the present century, there appeared the "Flora der Vorwelt," 1804, by Schlotheim; the works of Rhode and Steffens, 1810; and subsequently, from 1821 to 1838, the celebrated work of Count Sternberg, who was assisted in his arduous labours, especially in the late volume, by Corda and Presl. Corda himself afterwards published a valuable work on the structure of fossil wood, and Professor Goeppert has enriched the literature of coal-plants by numerous memoirs; of which the "Systema Filicum Fossilium," and his "Gattungen Fossilen," are very important. The coal-flora has been further noticed in the works of Von Martius, Unger, Endlicher, Cotta, Bronn, Germaix, and Gutbier, the last carefully describing the coal-flora of Zwickau. In Russia, the subject has been treated by Eichwald, and in Germany by Roemer and others. Professor Geinitz has admirably illustrated the coal-formations of Saxony in a work which contains many important observations; the coal-plants of Saarbrück have been partly described by Goldenburg, and those of the South Harz and Piesberg by Römer. Many interesting forms of fossil seeds or fruits have also

* Hooker, Quarterly Journal Geological Society, vol. ix, p. 12.

been described and figured by Dr. Berger and Professor Goeppert. Prussieu, Dulack, and Sauvage have contributed to the history of fossil plants in France, but the most important and valuable of the French works are those of Adolphe Brongniart, whose classic work, "Histoire des Végétaux Fossiles" (unfortunately not completed), is well known. Besides this, the various papers by the same author which have appeared in the French periodicals, including his important memoirs "On Sigillaria," and also the "Prodrome," published in 1827, and the "Tableau," in 1849, should be consulted by the student of the coal-flora. In America, attention has been directed to the subject by Dr. Granger, Dr. Hildreth, Dr. Newbery, and Mr. Wood.

Steinhauer published in the Transactions of the Philosophical Society of Philadelphia, for 1818, a memoir on fossil plants, including a detailed description of *Stigmaria*, the result of observations made by him in this country. Professor Dawson, in his "Acadian Geology," and in the "Journal of the Geological Society of London," has published many interesting researches on the coal-plants of Nova Scotia. The most important memoir, however, and that which has contributed most largely to our knowledge of the coal-plants of America, is the valuable work of Mr. Leo Lesquereux, which is appended to the Geological Survey of Pennsylvania; it contains many important remarks on the character and affinities of the fossil plants of the coal, their distribution and comparison with European species, as well as a description of two hundred and thirty-one species, and figures of one hundred and two of them. To the same author we are indebted for a catalogue of American fossil plants (including about two hundred and eighty species) published for the Scientific Society of Pottsville, Pennsylvania; and for other papers bearing on the subject which have appeared in the "American Journal of Science," vol. xxxii.

Passing to perhaps the more interesting portion of the subject—the consideration of the plants of Coal-measures in particular, it may be stated that in this country we have notices of coal-plants by Plott, in 1686; Woodward, in 1690; Llwyd, in 1699; Costa, in 1755; and at the commencement of the present century, by Morton, in 1809; Parkinson, in 1811; and subsequently, in the works of Artis and Mammatt, in 1827; Witham, in 1831; the "Fossil Flora" by Lindley and Hutton in the same year; and the interesting memoirs by Dr. Hooker; besides important papers published in various scientific journals by Bailey, Burney, Brown, Bunbury, Dawes, Harkness, Haughton, Hawkshaw, King, Pattison, Tate, and Williamson. The plants of the coal occur, as already stated, in an extremely fragmentary condition, although large portions of stems are sometimes met with; the different parts of the plant are rarely found in juxtaposition, the stem, root, leaves, and fruit being mostly isolated. These fragments are differently distributed; in the underclay, or clay below the coal-seams, the *Stigmaria*, with its rootlets, penetrating the bed in every direction, is very abundant, associated occasionally, with other plants. The coal itself contains compressed specimens of *Sigillaria*, *Stigmaria*, and *Lepidodendron*. But the most abundant remains are those found in the roof-shale and "trub" (a carbonaceous bed) and mostly parallel to the plane of deposition; these consist of Fern-stems and fronds (sometimes showing traces of fructification), also stems of *Calamites* (more or less compressed, and some feet in length), *Sigillaria*, *Lepidodendron*, and its fruits and leaves: occasionally, the *Sigillaria* are found in a vertical position and uncompressed, with their roots spreading out to some distance around. In the associated sandstone (as the flagstone series near Halifax) stems are chiefly found of *Halonia*, *Lepidodendron*, *Sigillaria*, and *Calamites*; rarely Fern-fronds but sometimes many fruits (*Trigonocarpon*) as in the Peel Delph quarry, near Bolton. The nodules of shaly ironstone, as at Low Moor, Coalbrookdale, and South Wales, frequently enclose remains of plants, especially Ferns, with the venation well defined; these are in a different condition to similar remains found in the shales: they are less carbonized, the vascular tissue being frequently filled with ferruginous matter, and thus preserved, whilst the cellular tissue is destroyed. Stems below the coal in Northumberland are associated with marine shells. These plant-remains occur in different states of preservation, generally compressed in the shales, or, when not so, their original structure destroyed; the outer part being converted into coal, the inner part being replaced by clay or sometimes coal. In the sandstone, the structure is mostly destroyed, except traces of the ligneous cylinder; a cast only remaining of the plant. The fronds of Ferns are generally well preserved, but when soriferous, or even otherwise, are usually attached to the shale by their under side. In some uncompressed specimens of *Lepidodendron*, *Sigillaria*, and *Stigmaria*, the tissues are well preserved, being replaced by iron, carbonate of lime, and pyrites, and sometimes silicified; thus allowing the original structure to be easily examined. The *Stigmaria* not unfrequently presents the vascular cylinder eccentrically placed, or even lying against the margin, the interior being filled with clay or sandstone. This eccentric position of the cylinder arises, as first noticed by Steinhauer, from the decay of the looser tissues, so as to allow the more solid portion to subside to the lower side when in an horizontal position. About three hundred species of fossil plants are recorded as found in the Coal-measures of England—the greater number consisting of Ferns, which are the characteristic plants, the larger portion of the remaining number comprising *Lepidodendron*, *Sigillaria*, *Calamites*, and some *Coniferæ*. Many species are widely distributed, although locally abundant, not only in our own coal-fields, but are common to those of Europe and America, and some have a great vertical range in the coal-measures. The most common forms are:—*Neuropteris cordata* (*N. hirsuta* of Lesquereux); *N. flexuosa; N. heterophylla; Cyclopteris orbicularis; Alethopteris lonchitidis; A. nervosa; A. Serlii; Pecopteris arborescens; P. polymorpha; P. arguta; Asterophyllites foliosa; Sphenophyllum Schlotheimii; Asterophyllites tuberculata; Calamites approximatus; Stigmaria ficoides;* some *Sigillariæ* and *Lepidodendra.* Of two hundred and twenty specimens examined by Mr. Lesquereux from the coal-fields of America, more than one hundred were identical with, and fifty others bore a close relation to, European forms, and which might prove to be the same when better specimens were procured. Sir C. Bunbury had previously alluded to the striking similarity of the two floras when describing the coal-plants of Maryland, and also those from Cape Breton, where, of thirty-seven species examined, twenty-four were identical with, and four or five others only varieties of, European forms.* Professor Goeppert enumerates eight hundred and seventy-nine species belonging to one hundred and

* Quarterly Journal Geological Society, vol. ii, p. 87; and vol. iii, p. 43C

twenty-four genera, of which species thirteen are classed as cellular, and eight hundred and sixty-six as vascular plants, of the coal-period. The *plantæ cellulares* comprise, of the *Aphyllæ*—two *Fungi* and eleven *Algæ*, there being no *Foliosæ*—neither *Hepaticæ* nor *Musci*. The *plantæ vasculares* comprise, Monocotyledones, seven hundred and thirty-five *Cryptogamiæ*, and thirty-seven *Phanerogamiæ;* and of Dicotyledones, twenty-one are *Monochlamydæ*, two *Christopetalæ*, and seventy-one doubtful.* On the other hand, Adolphe Brongniart† enumerates five hundred species of which, according to his arrangement, three hundred and forty-six are acrogens, and one hundred and thirty-three Gymnospermous Dicotyledons. The Cryptogamous Amphigens comprise four *Algæ* and two *Fungi*. The Cryptogamous Acrogens, two hundred and fifty *Filices;* eighty-three *Lycopodiaceæ;* and thirteen *Equisetaceæ*. The Dicotyledonous Gymnosperms include forty-four *Asterophyllitæ;* sixty *Sigillariæ;* twelve *Næggerathieæ;* three, probably, *Cycadeæ;* and sixteen *Coniferæ*.

With a view of showing the mode in which the fossil plants are distinguished from each other, it may be well to state that the whole of the numerous species and genera of plants are comprised in six classes. Firstly, there are the Thallogeous, or tongue-shaped plants, which include the *Algæ* and *Fuci*. Secondly, the Anogens, which include the Liverworts, Hepaticæ, and Mosses. Thirdly, the Acrogens, which include the Club-mosses, the Ferns, the Pepperworts, the Quillworts, and the Pillworts. Fourthly, the Gymnogens, which include the Conifers and the Cycads. Fifthly, the Endogens, comprising the Palms proper and Grasses. And, sixthly, the Exogens, which include the woody and strong timber-trees, such as the Birch, Apple, Pear, &c. Of the Thallogens we have very little evidence of development in the seas of the coal-period, perhaps because their structure is such that they were readily decomposed. Occasionally specimens have been found and are recorded by Brongniart, although the *Fucoides serrata* and *Fucoides dentata* are undoubtedly Graptolites. One only was found by Prestwich in the coal-measures of Coalbrookdale. *Fungi* are also scarce; the *Polyporites Bowmani*, referred to this class by

* Bronn, Index Palæontologicus, vol. iii, p. 727.

† Tableau des genres de Végétaux Fossiles, 1849.

Lindley and Lesquereux, requires further examination, and is probably a fish-scale. The *Excipulites Neesii* and *Gyromices Ammonis*, Göpp., also referred to the *Fungi*, and found attached to fronds and stems of Ferns, and in the shales of the coal, are considered to be identical with the *Spirorbis (Microconchus) carbonarius*, and to belong to the *Annelida*. Of Mosses, again, we have no distinct evidence, though Lesquereux thinks that he has discovered traces of them. The Acrogens embrace the great Fern tribes, and the fossil plants allied to the *Lycopodiaceæ*. Recent Ferns consist of roots, stems, branches or fronds, and certain organs of fructification, called sori and spores. But ere we enter upon the consideration of fossil Ferns we should look into some of the difficulties met with, even in the study of recent species, the classification of which is in part dependent on the character and position of the sori, or organs of reproduction; and these being mostly absent in the fossil species, their determination, or relation to existing types, is very unsatisfactory.

Some years since a paper was communicated to the Linnæan Society on the difficulty of determining the genera of plants embedded in the coal-shales; and the subject has been subsequently investigated by Dr. Hooker, in a valuable memoir published by the Geological Survey. A notion may perhaps be obtained of these difficulties, when it is known that the same form of venation may exist in very different ferns; as for example, in some species of *Gonioptrix*, *Stengoramma*, *Nephodium*, and *Meniscium*, and which could be distinguished by their fructification only. Hence we learn that similarity of venation does not necessarily indicate similarity of species, and that sometimes different venations belong to the same species. On the other hand, there are some Ferns in which the fertile and barren fronds differ considerably in shape, and others in which the outline of the frond varies, as in *Polypodium*, *Lundscea*, *Asplenium*, &c., which, in a fossil state, would render their determination difficult. Generally the fructification has been so modified by fossilization, that a frond with an indusium, and a frond without one, would present the same appearance. Brongniart, therefore, divides them according to the venation, and considers that the classification of fossil Ferns must be established on the nervation, and its relation with the general form of the pinnules and of the fronds.

Fossil Ferns are divided into three great groups. The *Pecopteridæ*, *Neuropteridæ*, and *Sphenopteridæ*. The first, *Pecopteridæ*, includes *Pecopteris*, *Alethopteris*, *Callipteris*, *Lonchopteris*, as well as probably *Woodwardites*. *Pecopteris* has generally large fronds, tolerably coriaceous, and divided into three or four branches, or are, as it is termed, bi-pinnate, tri-pinnate, or bi-tripinnatified. The bases of the leaflets are united to the stem. The leaflets have always a mid-rib, from which the secondary veins branch out towards the margin. In *Alethopteris* the pinnæ are thick, adnate, and decurrent; and the genus *Corynepteris* (Bailey) is probably the fertile frond, with hexagonal sori, of a species belonging to *Alethopteris*. In *Lonchopteris* the pinnæ have a mesial rib, and the secondary veins reticulate; *Woodwardites* has also reticulate venation, but the mid-rib is nearly obsolete; the British species referred to this genus probably belongs to *Dictyopteris*. The second group is the *Neuropteridæ;* they have the frond pinnate or bi-pinnate, the pinnules round or oblong, mostly entire, more or less free at the base, and without a mid-rib, except such as is formed by the union of the veins, and becomes obsolete towards the apex, or where the veins radiate directly from the base. This group comprises *Neuropteris*, *Odontopteris*, *Dictyopteris*, and some species of *Nœggerathia* and *Cyclopteris*. In *Odontopteris* the leaves are bi-pinnate, and attached by the entire base to the rachis, the pinnules are cuneiform, with no distinct mid-rib. *Nœggerathia* and *Cyclopteris* have also been referred to the same group, though doubts have been expressed of late concerning some species of the latter genus, which are considered, with some reason, to be merely the leaves of the Coniferous genus, *Dadoxylon*. In the *Dictyopteris*, again, the mid-rib is very nearly wanting, and the venation reticulate: it is found in the coal-measures of Saxony, Nova Scotia, and America. The third group is the *Sphenopteridæ*, which comprise a group of delicate ferns with the frond bi-pinnate or bi-pinnatified, the pinnules slender, more or less trilobed, and generally detached from the rachis. To this division belong *Sphenopteris*, *Hymenophyllites*, *Trichomanites*, *Schizopteris*. The genus *Sphenopteris* includes a large group of Ferns which present affinities with the recent genera *Dicksonia*, *Devallia*, and *Chelanthes*. The *Caulopteris* is a large species of Fern, or Tree-fern, of which the trunk is usually covered with so-called scars or oblong discs. These scars give the trunk a peculiar appearance; they are, however, merely the cicatrices left by the bases of fronds, similar to those scars observed in recent Tree-ferns from New Zealand and Jamaica.

Another characteristic plant of the coal-period is the *Lepidodendron* or scaly tree, which had a dichotomous branching stem, covered with rhomboidal or elongate scars, the bases of long linear leaves called *Lepidophylla;* the branches terminated by cylindrical cone-like bodies containing seeds, and termed *Lepidostrobi*. The internal structure consisted of a central continuous vascular cylinder, surrounded by a mass of cellular tissue, from the former of which arose vascular bundles, which proceeded more or less obliquely through the cellular portion to the bases of the leaves.

To the family *Lepidodendræ* belong also the *Ulodendron*, *Bothrodendron*, and *Halonia*; the last was probably the root of *Lepidodendron*, and was furnished both with small scars and prominent tubercles.

The family *Sigillariæ* includes two characteristic forms, *Sigillaria* and its root *Stigmaria*.

Sigillaria has a fluted stem with oval, pentangular, or long scars, from the form of which the name of the genus was suggested (*Sigillum*, a seal).

The scars exhibit a more or less spiral arrangement. The *Sigillaria* was a large tree branched at its upper extremity. Goldenberg has found the fructification of this very interesting genus.*

The internal structure differed somewhat from that of *Lepidodendron*, and consisted of an internal vascular cylinder, not concentrically uniform as in that genus, but separated into wedge-shaped portions; to this succeeded a mass of cellular tissue, which was surrounded by an outer layer or bark.

Stigmaria was the root of *Sigillaria*, the outer surface is marked with mamillate tubercles, arranged quincunically, and giving insertion to long cylindrical rootlets.

* Flora Sarrapontanæ.

The internal structure of *Stigmaria* resembled that of *Sigillaria*, but the position of the vascular bundles in relation to the cylinder was somewhat different in the two genera.

Another plant very common in the Coal-measures is the *Calamites*, a reed-like plant, somewhat similar to the Bamboo, and formerly considered to belong to the same family, but the researches of Dawes, Binney, and others, have shown that the internal structure presents affinities to that found in Gymnogens, Endogens, and Acrogens. The stem was striated and jointed at intervals, around which were nodes or tubercles, which supported branches or leaves; these appendages being probably some of the forms referred to the *Asterophyllitæ*, a group of plants with slender stems and verticillate leaves, including *Bornia*, *Bruckmannia*, *Sphenophyllum*, &c.

Volkmannia possessed a cylindrical, fluted, and articulated stem, bearing tubercles or nodes at the joints, and terminated by an oblong cone-like body, consisting of numerous whorls of short subulate leaves, a combination presenting some analogy to the genus *Ephedra*, as pointed out by Dr. Hooker.*

The last principal group is the *Coniferæ*; it abounded, but not in the same proportion as the others.

But few remains of cones or leaves have yet been found. The evidence of *Coniferæ* being chiefly dependent on the structure of the woody tissue, which is specially marked by pores surrounded by large discs, and arranged in the fibres of the wood either in a single row or in double or treble rows, as in *Araucaria* which the coal-wood most nearly resembled. The genera *Pitus*, *Peuce*, *Pissadendron* belong here. One genus, *Dadoxylon* is remarkable for its large pith, the cast of which was formerly described under the name of *Sternbergia* and *Artisia*. The *Dadoxylon* is considered by Salter and others to be the tree of which some forms of *Cyclopteris* are the leaves, and *Trigonocarpon* the fruit.

Of the 300 fossil plants found in the British Coal-fields, more than one-half are Ferns. Of the 900 Coal-plants enumerated by Goeppert the greater part are vascular cryptogams; and Brongniart states that out of 500 coal-plants, 350 belong to the same class.

* Quarterly Journal Geological Society, vol. x, p. 199.

From the above brief remarks it may be observed that the flora of the Carboniferous period was characterized by the absence of the Dicotyledonous Angiosperms, and the paucity of Monocoty ledons, and by the presence of Gymnogens, the predominance of the Acrogens, and the great development of a peculiar group of plants, namely, the *Sigillaria* and allied forms,—plants having affinities on the one hand with the last division, and on the other with the Dicotyledonous Gymnosperms.

That the old Coal-flora was uniform over a considerable area there can be no doubt, for Lesquereux mentions that of two hundred and thirty American coal-plants, one hundred are identical with European plants, and with regard to many others he might not be able to discover the difference after more careful comparison. When the plants of the Coal-period are studied, it will be seen not only that there was a considerable extent of country occupied by the coal-formation, but that the period was one that indicated a humid or moist climate, and that there must have been some peculiar physical conditions by which such a luxuriant vegetation was supported.

In the subsequent discussion, Mr. G. E. Roberts said, that with respect to the *Corynepteris* of Bailey, he had brought a specimen in which the hexagonal sori were well shown; it had recently been found in the coal-field of the Titterstone Clee Hills.

The Rev. Mr. Wiltshire enquired whether in the different beds of coal, or in the upper and lower portions of the same seam, different plants were met with? They all knew that, taking rocks generally, different fossils were found in the different strata, and he should be glad to learn whether a similar arrangement was observable in the coal.

Professor Morris said that that was a question that could scarcely be answered at present. It was only in a very fragmentary state that the specimens were usually obtained, and, in consequence, portions of the same plants had been described as distinct species; for instance, in the genus *Sigillaria*, were included many so-called species which were parts of the same stem, in different states of preservation, as pointed out some years ago by Mr. Binney and Professor King.* The prevailing opinion seemed to be that there is a great uniformity in the plants of the upper and lower portion of the coal-measures; in Yorkshire and Lancashire there are certain plants which occurred in the bottom coal more than in the other, many of these had been carefully worked out and described by Mr. Binney.† Lesquereux had also pointed out that there were plants more common in the lower than in the upper coal; but the subject was one requiring further investigation, and could only be undertaken by those who had ample opportunities of examining specimens from shales over different coal-seams, or from the different beds passed through in sinkings for coal.

Ordinary Meeting, Monday, December 1st, 1862.

Professor Tennant, F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—H. Mackillop, Esq.; Fredk. Wm. Hadden, Esq.; and — Dé Burglio, Esq.

The following donations were announced:—

Presented by Mr. E. S. Biden.

"*Catalogue, Victorian Exhibition.*"

"*Guide to the Land-law of Victoria.*"

"*Supplement to Catalogue of the Products of the Colony of New Brunswick.*"

"*The Products and Resources of Tasmania.*"

"*Imperial and Royal Geological Institute of the Austrian Empire—Catalogue of the Mining and Metallurgical Products: Class I., International Exhibition.*"

"*The Smithsonian Report for* 1860." By the Smithsonian Institution.

"*Indian Catalogue, International Exhibition.*" By J. Forbes Watson, Esq.

* Edin. Phil. Journ.

† Quart. Jour. Geo. Soc., vol. xviii, p. 106.

"*Quarterly Journal of the Geological Society*, No. 72." By the Society.

"*On the Motion of Camphor towards the Light.*" By C. Tomlinson, Esq.

"*Annual Reports of the Royal Cornwall Polytechnic Society since* 1833." By the Society.

By the President.

"*Works of Art and Jewellery—Descriptions of the Chief Productions of Hungary.*"

"*Routledge's Guide to the Exhibition.*"

"*Geological Survey of Canada.*"

"*Illustrated Catalogues of Works of Art in the International Exhibition.*"

"*Address delivered at the Opening Meeting of the British Association at Cambridge.*"

The following paper was read:—

"On the Application of certain Processes in Technology to the Explanation of Geological Phenomena." By C. Tomlinson, Esq.

Annual Meeting, Monday, January 5th, 1863.

Professor Tennant, F.G.S., President, in the Chair.

The Annual Report was read as follows:—

REPORT.

In commencing a new year it may be necessary to take a brief retrospect of the past, and as far as possible to survey the future prospect.

During the past year our monthly meetings have been held with regularity. A number of interesting papers have been read, and some lively discussions have been provoked on debatable points.

The following papers have been read during the year:—

"On Lime and Limestones." By Professor Tennant, F.G.S.

"On the Ancient Flint Implements of Yorkshire, and the Modern Fabrication of the same." By Rev. Thos. Wiltshire, M.A., F.G.S.

"On the Cretaceous Group in Norfolk." By C. B. Rose, Esq., F.G.S.

"On Skulls and Flint Implements found in the Essex Marshes." By E. Cresy, Esq.

"On Bone-beds, their Occurrence in Sedimentary Deposits, and Probable Origin." By G. E. Roberts, Esq.

"On a Superficial Freshwater Deposit near the Blackfriars-road." By C. Evans, Esq.

"On Mine Surveying and Planning." By M. W. J. Scott, F.G.S.

"On Diamonds." By Professor Tennant, F.G.S., President.

"On Coal Plants." By Professor Morris, F.G.S.

"On the Application of certain Processes in Technology to the Explanation of Geological Phenomena." By C. Tomlinson, Esq.

One of the characteristic features has also been prominent during the past year, viz., excursions to geological sites and collections of interest, among which may be particularly distinguished, the International Exhibition. At Cambridge, Messrs. Carter and Seeley, Professors Babington and Miller, and other distinguished men rendered considerable service in pointing out the various objects in the museum and neighbourhood. At Lewes, the Rev. T. Wiltshire, Captain Noble, and Mr. Godbee, did much to render the excursion useful and agreeable. The hospitality of the last named gentlemen in receiving the members into his house and grounds, and supplying them with refreshments must not be passed without notice. A similar expression of gratitude is due to Mr. Carter, of Cambridge.

At the International Exhibition, a large number of gentlemen connected with the building, and also with this Association, devoted their time and talents to several lectures and explanations on the various objects of interest in the building connected with geology and mineralogy, mines and mining, &c. The services thus rendered are too numerous to be individualized, but it may be mentioned that the Association has endeavoured to express its gratitude by proposing that Sir W. Logan, Professor Sanguinetti, the Rev. D. Honeyman, and Dr. Wedding, be elected honorary members.

A large party also visited the Main Drainage Works, and were hospitably entertained by Mr. Cooper, the Engineer of the works, while Mr. Lovick explained the general features of the whole scheme.

With respect to the Library of the Association, the books of which are freely circulated among the Members, some considerable additions have been made during the past year; the most valuable of which are the complete Monographs of the Palæontographical Society, containing upwards of 11,000 figures of British Fossils. The books now in the library number 36,* ready for circulation, and it appears that nearly 50 issues of books have been made since the library was first opened in March last, which may be considered as very satisfactory, and as showing that the library, though it be but small, is nevertheless fully appreciated.

The following fossils have been presented during the year:—

Peat-bed fossils, 15 species; and Crag fossils, 68 species; } By J. Pickering, Esq.

Cast of Tooth of Mastodon. By C. R. Rose, Esq.

Fossils. By Mrs. Stabb; and other fossils by C. Evans, Esq.

Fossils from the Lower Greensand. By C. J. A. Meijer, Esq.

Fossils from the Brick-earth of Norfolk. By C. R. Rose, Esq.

Fossils from the London Clay of Hampstead. By C. Evans, Esq.

The number of Members who have retired during the past year has been 16. The new Members elected are 46. The number of Members on the books of the Association is steadfastly increasing.

The accounts continue satisfactory, the balance now in the Treasurer's hands is £62 18s. 1½d. as against £54 1s. 11½d, at the last annual meeting. The expenditure for 1861 was £97 17s. 10d., that for the past year has been £126 17s. 2d. Thus, notwithstanding increased expenditure, there is an increased balance in hand. During the coming season, papers have been promised by Mr. Cresy, Mr. Bensted, the Rev. T. Wiltshire, W. Tomlinson, Mr. Rupert Jones, Professor Tennant, and others.

We have also been invited to visit Dudley, Malvern, Ipswich, Harwich, Bath, Bristol, Maidstone, Reigate, Cambridge, and Oxford.

* Additions have been made to the Library since this Report was read (see list of Books appended to this No. of Proceedings).

Visits to the British Museum and the South Kensington Museum, the College of Surgeons, Kew Gardens, and the Zoological Gardens will probably be made.

It is proposed to make further additions to the Library, so as to include Dana's new work on Geology, the reports of the International Exhibition of 1862, the Proceedings of the Geological Society, Lovell Reeve's British Shells, Phillip's Geological Map of the British Isles, &c.

The Committee have made proposals to various Field-clubs and Geological Societies in the country, with a view to the exchange of their Proceedings for those of this Association. These proposals have been well received, and several societies now regularly forward their publications to the library.

The Committee beg to recommend the following list of officers for 1863:—

PRESIDENT.

Professor J. Tennant, F.G.S., &c., 149, Strand, W.C.

VICE-PRESIDENTS.

Dr. Lister, F.G.S.	T. Sopwith, Esq., M.A., F.R.S.
J. Pickering, Esq.	Rev. T. Wiltshire, M.A., F.G.S.

TREASURER.

Wm. Hislop, Esq., F.R.A.S., &c., 108, St. John Street Road, E.C.

GENERAL COMMITTEE.

A. Bott, Esq., A.A.	Thomas Lovick, Esq.
T. Brain, Esq.	B. Marriott, Esq.
E. Cresy, Esq.	Dr. C. T. Richardson.
C. Evans, Esq.	G. E. Roberts, Esq.
S. Highley, Esq., F.G.S.	J. Rofe, Esq., F.G.S.
W. N. Lawson, Esq., M.A.	C. Tomlinson, Esq.

HONORARY SECRETARY.

J. Cumming, Esq., F.G.S., 7, Montague Place, Russell Square, W.C.

HONORARY LIBRARIAN.

A. Bott, Esq., A.A.

It was moved by the Rev. R. Bingham, seconded by Mr. Leighton, and carried, that the Report be adopted.

The following is a copy of the Balance-sheet:—

GEOLOGISTS' ASSOCIATION.

Balance-sheet, December 31st, 1862.

	£	s.	d.		£	s.	d.
By Annual Subscriptions and Entrance-fees....	113	3	0	Rent and House-expenses	27	13	4
By Life-subscriptions ..	18	18	0	Printing and Engraving for Proceedings	49	9	6
By Interest on Stock ..	3	12	4	Editing and Reporting ..	10	1	0
By Balance on last account..............	54	1	11¼	Books, Binding, &c	16	15	6
				Postage, Stationery, &c...	18	15	1
				Commission to Collector	1	7	0
				Sundry Expenses	2	15	9
					126	17	2
				Balance in Treasurer's hands	62	18	1¼
	£189	15	3¼		£189	15	3¼

We have this day examined the accounts of the Treasurer of this Association and find a balance of £62 18s. 1¼d. in his hands.

(Signed) CHRISTOPHER THOS. RICHARDSON.
WILLIAM H. LEIGHTON.

December 31*st*, 1862.

Notice of motion having been given at two previous Ordinary Meetings,

It was moved by Mr. Bott, seconded by Mr. E. Jones, and resolved unanimously,—"That the subscriptions of Country Members, elected after this date, be Ten Shillings, instead of Five Shillings, as heretofore; and that the composition for such Members as Life-members be £5 5s., instead of £3 3s.

Ordinary Meeting, Monday, 5th January, 1863.

Professor Tennant, F.G.S., President, in the chair.

The following gentleman was elected a member of the Association:—D. R. Harrison, Esq.

The following donation was announced:—

"*Dr. Mantell's Pictorial Atlas.*" By Mr. Leighton.

The following paper was read:—

"On the Distribution of the Fossils of South America." By Carter Blake, Esq.

Premising his remarks by a statement of the general paucity of the fossil remains of fishes, reptiles, and birds in the South American continent, Mr. Blake attempted to offer a hasty sketch of the geographical distribution of the principal forms of fossil Mammalia, which had been obtained through the energetic scientific researches of active travellers and accurate observers, like Darwin, Castelnau, Gay, D'Orbigny, Bollaert, Cuming, or Forbes. At the outset he laid great stress upon the generalization which had been universally arrived at by palæontologists, that the geographical distribution of fossil Mammalia in the Pliocene strata of South America was nearly the same as in the present day. The fossil types were then, as now, restricted to the forms which had been termed *neotropic* by the physical geographers. The tapir, and not the hippopotamus, slaked his thirst in the tepid waters of the Amazon; the llama, not the camel, ascended the steep cliffs of the Cordillera de los Andes, or traversed the arid pampas of Patagonia; the mice, like those of existing South America, were restricted to the genus which Waterhouse had termed *Hesperomys*. Glancing briefly over the distribution of the fossil Pliocene Mammalia, Mr. Blake remarked that the *Monotremata*, now confined to the Australian region, were not unnaturally absent in South America. *Marsupialia* were represented by small opossums; *Rodentia* by fossil animals allied to the coypú, the páca, the capybára, and the agúti of existing Brazil; *Cheiroptera* by bloodsucking bats; and *Bruta* by those gigantic forms which had been obtained from the Pampean deposits, and amongst which *Megatherium*, *Mylodon*, *Megalompys*, *Glyptodon*, *Scelidotherium*, and many other examples were offered. An illustration was given of the mode employed by palæontologists in reasoning by the aid of the "correlation law," as applied to the reconstruction of the skeleton of Megalonyx from the solitary unequal phalanx originally discovered by the President of the United States, Jefferson. The restorations of the carapace of the gigantic Glyptodons and Schistopleurs were commented on in detail. Passing over the orders *Cetacea* and *Sirenia*, the *Toxodon*, apparently allied to the Dugong and the Dinotherium, but with many analogies to the guinea-pig, was noticed. Turning to the order *Proboscidea*, Mr. Blake adhered to the opinion he had previously published respecting the Texan elephant, and roughly sketched the distribution of elephants from Behring's Straits to Guiana, and of mastodons from the northern districts of America to Lake Taguatagua, in Chile. The *Macrauchenia*, allied to the tapirs, but with a stiff neck like the llamas, was noticed; it ranged from Bolivia to Patagonia. The horse was introduced into America by Columbus; in the year 1537 it made its appearance at Buenos Ayres; forty-three years afterwards, we find it at the Straits of Magellan. Prior, however, to the human epoch, we have evidence of many species of horses in both North and South America. The Ruminant order was referred to as represented by stags and antelopes, which were preyed upon by the large carnassial *Machairodus*, with sabre-shaped teeth, and by a small cat, closely resembling the cheetah of India. The monkeys of South America all belonged to the same great group of prehensile-tailed monkeys as now inhabited South America. The evidences of man's antiquity were few and far between. Near Lake Minas Geraes we have human remains with those of extinct animals, and traditions existed amongst the Indians of the existence of a gigantic ape, the *Cayporé*, which might possibly be identified with the *Protopithecus* of the Pleistocene strata of Brazil. Such evidences, however, were inadequate for the deduction of any generalizations respecting the antiquity of man in the South American continent. The broad fact of the coincidence of the fauna of the Pliocene period in South America with that of the present day was alluded to; and the insufficiency of the present state of our knowledge of South American Palæontology for founding any confident generalization was especially brought under notice."

A discussion followed the reading of the paper, in which the President, Waterhouse Hawkins, Esq., F.G.S., and J. S. Mackie, Esq., F.G.S., took part.

CATALOGUE OF BOOKS IN THE LIBRARY.

Advanced Text-book of Geology		D. Page.
British Fossils.	The Univalves of the Crag	S. V. Wood.
"	The Bivalves of the Crag	S. V. Wood.
"	The Polyzoa of the Crag	G. Busk.
"	The Tertiary Echinodermata	E. Forbes.
"	The Tertiary and Cretaceous Entomostraca	T. R. Jones
"	The Fossil Cirripedia	C. Darwin.
"	The Reptilia of the London Clay and other Tertiary Beds	Owen and Bell.
"	The Reptilia of the Cretaceous Formations	R. Owen.
"	The Reptilia of the Cretaceous, Wealden, and Purbeck Formations	R. Owen.
"	The Cretaceous Cephalopoda	D. Sharp.
"	The Oolitic Echinodermata, vol. i.	T. Wright.
"	The Great Oolite Mollusca	J. Morris and J. Lycett.
"	The Fossils of the Permian Formation	W. King.
"	The Tertiary, Cretaceous, Oolitic, and Liassic Brachiopoda	T. Davidson.
"	The Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals	Milne, Edwards and J. Haime.
Bridgewater Treatise, 2 vols.		W. Buckland.
British Land and Fresh-water Shells		L. Reeve.
Catalogue of British Fossils		J. Morris'
Cruise of the "Betsey"		H. Miller.
English Cyclopædia, Natural History, vols. i, ii, iii, iv		C. Knight.
Fossils of the British Museum		G. A. Mantell.
First Impressions of England and its People		H. Miller.
Foot-prints of the Creator		H. Miller.
Geological Society, Abstracts of Proceedings.		
" Quarterly Journal.		
Geology of Weymouth and the Isle of Portland		R. Damon.
Geological Excursions, Isle of Wight, &c.		G. A. Mantell.
Geologist, The vols. 2, 3, 4		S. J. Mackie, Ed.
Geology: Is it antagonistic to Scripture?		
Geology in the Garden		H. Eley.
Geology and Fossils of Sussex		F. Dixon.
Geology of the Mountain-limestone District		J. Phillips.
Geology of the Yorkshire Coast		J. Phillips.
Glossary of Mineralogy		H. W. Bristow.
Handbook of Geology		D. Page.
Historic Society of Lancashire and Cheshire. Transactions. Vols. i, ii.		
Indian Catalogue. Exhibition, 1862.		

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

No. 10.] [Session 1863–64.

Ordinary Meeting, Monday, February 5th, 1863.

Professor Tennant, F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association :—Messrs. George Robert Jebb, W. M. Wake, James W. Ilott, James How.

A paper was read,

"On the Remains of Mammalians and other Fossils in the Crag Formation." By Mr. E. Charlesworth, F.G.S.

Ordinary Meeting, March 2nd, 1863.

Professor Tennant, F.G.S., President, in the Chair.

The following lady and gentlemen were elected members of the Association :—Miss Florence Deedes, Mr. Cecil Deedes, Mr. Robert Rawlinson, C.E., Mr. Mainwaring Shurlock.

The following donations were announced :—

"*Abstract of Proceedings of the Geological Society.*" By the Society.

"*Transactions of the Tyneside Naturalist's Field-Club*, Vol. 5, Part 4." By the Club.

"*Quarterly Journal of the Geological Society.*" By the Society.

The following papers were read:—

1st. "On the Lead-mines of England." By Mr. Sopwith, M.A., F.R.S., F.G.S., &c., Vice-President.

The importance of the mineral products of the North of England is so great that a general description of them and of the geological conditions connected with mining might probably interest the members present.

In speaking of coal, the author remarked that he thought it important to keep in view its conservation. He was aware that it was calculated that the quantity in this kingdom is so large that we need not trouble ourselves about it, but he was not entirely of that opinion. The question does not depend so much upon the quantity of coal that exists as upon the economy with which it can be worked. There are many mines in which, although there is much coal, yet from various causes much of it will not be obtained. The thickest seams are usually first worked, leaving the smaller ones, and some of these will never be worked at all. Very often one seam is much damaged in the working of another. Inundations also give a state of things which cannot be remedied except by combined efforts by adjoining proprietors—individual means being insufficient to carry out the necessary works.

Having alluded to recent discoveries of iron-stone, which added to the importance of the North of England as a mining district, Mr. Sopwith said his more detailed explanations would chiefly have reference to the lead-mining districts. These were comprised in a wide territory, lying about the junction of the counties of Northumberland, Durham, and Cumberland, with adjacent districts in Yorkshire. Looking at a map of England, it would be seen that the district thus indicated is very nearly in the centre of the kingdom, and it is marked by a chain of hills extending in a north and south direction nearly midway from sea to sea in the narrowest part of the island, and also midway between the north of Scotland and the southern shores of England.

An excellent description of the scenery of this range of hills is given in Conybeare and Phillips' Geology of England and Wales, of which he might say in passing that it was one of the ablest geological works which had appeared in England. Taking into account the early period of geological science in which it was written, it was most instructive; and even now he often recommended it as being one of the best works a student could read. Some of the passages are peculiarly descriptive, as fŏr example—"The whole of the Penine chain is composed * * * characterising the beds of this formation."* He would read another extract from the same book to show the admirable manner in which the authors combine the picturesque with the practical and useful—"The features of this chain are often very wild * * * and the setting sun twice on the same evening."† This incidental notice would serve to picture to the mind the wild and picturesque nature of the scenery; and with regard to the geology of the district, he should have principally to direct them to what is now usually known as the Carboniferous formation. The first point would be to find its relative position in the scale of the English stratified rocks generally. Supposing the whole range of these rocks to be represented by a scale seven feet in height and divided into seven equal parts, the space between the third and fifth divisions from the bottom would be about the space which the Carboniferous formation would occupy The lower six of the twelve inches of this space would represent the lead-measures, and the others the coal-formation. As regards the particular beds which are found in these two formations, the upper portion is marked by a great number of seams of coal, from three to four or five feet in thickness, with many smaller seams; these extend over a large area of the eastern portion of the district of which he was speaking. The measures gradually rise up from the sea until we come to the district of Crossfell, and beneath this the beds of the eastern part of the North of England—shale, schist, and sandstone—are seen. After the coal crops out we find the beds of sandstone, and then some twenty beds of limestone occur, all of which are visible on the western side of Crossfell Mountain, whose

* Vide "Outlines of the Geology of England and Wales." By the Rev. W. D. Conybeare and Wm. Phillips. London, 1822. Part I, page 366, line 24, to page 367, line 30.

† Vide *op. sup.*, page 367, line 31, to page 368, line 4.

summit is 2,901 feet above the level of the sea; there is a great dislocation on this side of the mountain, the strata having dropped four or five thousand feet, or, which would produce the same result, the mountain itself has been uplifted, affording an interesting subject of study to any one who would consider the regular sequence of deposition of the various beds. The beds of coal and ironstone eastward are highly important; and instances will be met with of denudation having taken place to more than the extent and the height of the mountain just spoken of. There is evidence of strata, of the thickness of four or five thousand feet, having been lifted up into an inclined position, and we should have to sink four or five thousand feet in the plain to find the strata which occur at the top of the mountain.

He would next direct their attention to a series of geological models which he made some twenty years ago, and which he had frequently found useful in explaining the manner in which mineral deposits occur. In the first place, nearly all mineral veins are dislocations, though often of more moderate extent than that of which he had been speaking. The first model represented the Great Limestone, which is so called because it is the thickest of the beds occurring in the district. He had prepared a Table, giving the list of rocks above and below this bed of limestone, and the quantity of lead worked from each, that they might appreciate the importance of the Great Limestone. This they would at once do when he told them that from the Great Limestone there was produced in Alston Moor, in three years, 14,397 tons of ore, whilst no other formation yielded more than 500 tons. It was from the importance of the Great Limestone that he was induced to construct the models, with a view of showing the relation of the various rocks in the district. To enable them to understand the subject, he explained a section and view of a valley of denudation. They would see that beds which were in fact perfectly level, did not, at the surface of the valley, present a uniform aspect; the consideration of this is of importance to those who would understand the delineation of strata upon maps. Having seen the denudation of strata, and some of the effects on strata, he would call their attention to a model which shows a dislocation, causing a single lode to appear as two. They might expect to find a precipice left where the strata have gone down, and it was owing to an action of this kind that they got the appearances met with at Crossfell. The western escarpment of Crossfell is very steep, which is owing to the displacement, but it has been somewhat softened down by ages of wearing. It is usually found that where displacement has taken place at the surface, it appears to be such as would be compensated by other actions, an instance of which they would see in the diagram before them; here the coal had been upheaved in the middle of the deposit, and the fold thus formed had afterwards been denuded. The importance of these dislocations is immense, and perhaps in no case more so than with respect to our coal-measures; without dislocation many of the best coal-seams would have been altogether inaccessible. As it is, the same beds sometimes appear three or four times near the surface; but it should be remembered that the effect of these dislocations is also to separate the same seam of coal; it being possible to put down a shaft which, if continued to the centre of the earth, would never cut the coal although the seam was on each side of it; it is in such cases as these that geology is of use to the practical miner. A practical man cannot commence large operations with anything like certainty of success unless he has accurate geological knowledge. Looking at a section of Hartley Burn, they would see that a level might be driven under all the coal without cutting a seam. It is not merely the geological appearance at surface, but also the dip or inclination of the strata that must be considered; for sometimes it is of very great importance to know where to find the hard and the soft rocks, so as to sink and drive as much as possible in the soft, and to avoid the very hard, in working to reach a particular point. A mineral vein is a crack or dislocation, so that what a mineral-miner looks for carefully as a lode a coal-miner avoids as a fault or trouble. The next model represented the singular effect produced when successive faults or dislocations of strata are shown on one horizontal intersecting plane, such a plane as would represent the range, or, as miners in the lead-districts would say, "random of the level." He might mention with respect to this that Mr. Buddle, the eminent colliery viewer, remarked, when he saw it, that if it had not been for the certainty of an exact model, he would not have believed the results here shown to be possible. The next point was one which could be advantageously studied in every mining district, and one of much importance to those exploring new districts; it is important in a new country to be able to offer an opinion as to whether the underlying rocks are steep or lie at a moderate angle, and this may be ascertained with comparative ease. When the stratal dip is less than the valley in which the inspection is made, the outcrop of the strata will form a Λ pointing up the valley, but when they are more steep, the V will point down the valley; this arises because the order of stratification is reversed. He might mention that all the models he had shown them were meant to represent the country of which he had been speaking.

He would endeavour to describe some of the phenomena connected with mineral veins. The works of Nature being on so vast a scale, we can scarcely comprehend them, so it is better to consider part of a country, say a square of forty or fifty miles, on a scale of one inch to a mile; on such a model, the size of an ordinary dining-table, Crossfell mountain although only three or four hundred feet short of the highest elevation in the kingdom, would be represented by a projection of no more than three-fifths of an inch high. Whilst three-fifths of an inch would represent the height of the mountain, one-eighth of an inch would represent the average level of the country above the sea, and if they could consider this one-eighth of an inch to be divided into several thousand laminæ, they would readily conceive that if water were thrown upon the model, when it dried, a crack of half an inch or so might occur; and, admitting that the drying would produce cracks, they had only to suppose a few of those cracks in a model the size he had mentioned, and they would have such an amount of dislocation that it would then become a wonder that so great order prevails. In the North of England, the strata from the east coast rise from the west, and in one of the diagrams before them, the level is driven where the strata are almost perfectly level. The great value of the lead-deposits of the North of England arises from the horizontal position of the strata. In looking at the deposits in this district, they would observe, from the sections in which he had taken the Great Limestone as the standard, and placed it always at the same level, that in all the different places represented there is a remarkable similarity in the strata, and he might remark that in this respect the district differed very materially from most other mining districts. The deposits of ore in the North of England lie in a regular and nearly vertical position, instead of in irregular or zig-zag veins; which, however curious in a geological point of view, were anything but desirable for those who had to work in them as mines. In order to suit the miner, the strata require to be upheaved, depressed, and dislocated, to place them easily within his reach. These dislocations were well shown in the district he had been speaking of. But for this uplifting and dislocation, one or two beds only being available, all the others would have been at a depth beyond our reach. He had endeavoured to give them some account of the lead-mines of the North of England, and to show that without a knowledge of geology, great errors may be made in mining; indeed, it was well known that such had been made, and that families had even been ruined in consequence. He would conclude with an anecdote. They were all aware that a vast number of rocks are concretionary, formed in the same way as the "fur" on the inside of a kettle. At the Walker Colliery some fifty years ago, a stream of water, which flowed from some of the working places in the mine, passed along a wooden pipe, placed at a small inclination. This water deposited mineral matter in its course, to the thickness perhaps of a thin sheet of writing-paper each week. There was a thin deposit after twelve hours, and as, during the time this deposit was taking place, the traffic of the men made the water dirty, the deposit was very dark coloured or nearly black; then, as the men did not work at night, there was a deposit of much lighter colour in the nearly clean water which passed along the pipe. The next day there was another black deposit, and the next night another light deposit, so that at the end of a week there would be six of each; and as the men did not go into the pit on the Sunday, there was an additional light line, or rather the light line which followed the Saturday was considerably widened, and thus represented the longer interval from Saturday night until Monday morning. A specimen of this stone is now in the Ashmolean Museum at Oxford. Upon examining the stone it was found that, instead of the six alternate black and white marks, and then the broader line for Sunday, there were some differences and irregularities. There were three consecutive days altogether black, and it was subsequently found that this represented three days when the men had worked double shifts. This would not perhaps have been known, but fortunately there followed a Tuesday which was all light, and in the following week again there was a Thursday all light. This was at once an explanation; the Tuesday was discovered to be the day when the pitmen annually attended a cock-fight in the neighbouring town; and the Thursday was the day upon which the gold cup was run for at the Newcastle races, so, of course, the colliers were away again. Upon comparing the accounts as shown by the stone and the pay-ledger, it was found that they agreed exactly, the weeks referred to occurring in the month of June. He might tell them that this "Sunday stone" was used by the late, and he believed by the present Professor of Geology at Oxford, and he thought that they would admit that this "Sunday stone" formed as good an example of theological geology as could be wished for.

The President said that he was sure they would all unite with him in offering their best thanks to Mr. Sopwith for the very interesting paper he had given them. It was, in fact, only an abridgment of a long life of study, and as Mr. Sopwith has from two to three thousand persons employed under him, it would be seen that he had great facilities for acquiring experience. Mr. Sopwith had written an account of the Hartley Colliery Accident in the St. James's Magazine, containing an interesting account of the difficulty of working underground. The mineral wealth of this country reaches no less than forty millions sterling, but if any one wished to invest his capital in mines, he should alway take care to get reliable advice before doing so. People would not be contented with three per cent. for the money, when they thought there was a chance of getting three times as much, but some of his intimate friends have lost much money by improvident adventures. One had told him that he was promised ten per cent. for his money, instead of which there had been nothing but calls ever since. With regard to the district and mines of which Mr. Sopwith had been speaking, he might observe that he, the President, would be sorry to be asked some of the questions of a mining character which were asked of the children in the schools about the mines, and to show how much advantage had been derived from science, he might tell them that instead of letting the poisonous fumes from the lead-smelting escape as it used to do, carrying much lead with it, the chimneys of the smelting works were now made miles in length, and a large quantity of the lead from those fumes deposited in them.

After some remarks from Mr. E. Charlesworth, F.G.S., the thanks of the meeting were given to the author of the paper.

2nd. "On Paramoudras." By Mr. E. Charlesworth, F.G.S.

Mr. Charlesworth exhibited several specimens of Paramoudras, and the general tendency of his remarks was to show that, in his opinion, they were mere aggregations of flint.

A discussion followed, in which Mr. Rose, Mr. Cumming, Mr. Norton, and the President joined.

Ordinary Meeting, Monday April 6th, 1863.

Professor Tennant, F.G.S., President, in the Chair.

The following gentleman was elected a member of the Association:—Mr. John Cole, F.R.A.S.

The following donations were announced:—

"*Abstract of Proceedings of the Geological Society.*" By the Society.

"*Transactions of the Historic Society of Lancashire and Cheshire.*" 2nd Vol. By the Society.

"*Introductory Address of the Study of Anthropology.*"

"*Quarterly Journal of the Geological Society from* 1850 *to* 1852, 1854, 1855 (1856 *to* 1863, No. 45 to 73)."

"*Address at the Anniversary Meeting of the Geological Society,* 1855."

"*Proceedings of the Royal Geographical Society,* 1857, Vol. I, No. 9, 10; 1858, Vol. 2, No. 1 to 6; 1859, Vol. 3, No. 1, 2, 3, 5, 6; 1860, Vol. 4, No. 1, 2, 3, 4, 5; 1861, Vol. 5, 1, 2, 3, 4, 5; 1862, Vol. 6, 1, 2;" and the Journal of the Society for the years 1854, 1855, 1856, 1857. By E. C. Ravenshaw, Esq.

The following papers were read:—

1st. "On Fossil Sharks." By Mr. E. Charlesworth, F.G.S.

This led to a discussion, in which Messrs. Carter Blake, Cresy, Waterhouse Hawkins, and the President, took part.

2nd. "On Fossil Monkeys." By Mr. Carter Blake, F.G.S.

Mr. Carter Blake endeavoured to give a short sketch of the state of our knowledge relative to the geological and geographical distribution of the principal forms of fossil monkeys. No well ascertained evidence of fossil monkey had yet been derived from Eocene beds, the so-called *Eopithecus* or *Macacus eocœnus* having been recently admitted by its original describer, Professor Owen, to be merely founded on specimens of a small pachyderm, *Hyracotherium cuniculus*. In Miocene beds in the South of France, as well as in Germany, we had specimens of long-armed ape, *Pliopithecus* and *Dryopithecus*, allied to the existing Gibbon (*Hylobates*) of the Ganges: and in Greece were some small-tailed monkeys (*Mesopithecus*). In the Pliocene strata we have distinct evidence of the existence of a macaque monkey (*Macacus pliocœnus*) from Grays in Essex; as well as many proofs in South America of the remains of monkeys allied to the forms there now existing and grouped under the genera *Protopithecus*, *Cebus*, and *Callithrix*. In Africa where the existing apes included amongst them two forms, the gorilla and chimpanzee, nearest resembling man, no geological explorations had been made of sufficient success as to afford us proof of the presence of fossil monkeys. The same rule was applicable so far as regards the land of the oran-útan, the Asiatic Archipelago. Future investigations in these localities might afford us some interesting evidences; nevertheless it was a singular fact, that in Australia, the country where at present the lowest forms of man exist, there were no monkeys, either recent or fossil. It was not Mr. Blake's province to attempt to offer any explanation of these facts, but merely to lay them before the Association. Up to the present time, our knowledge of fossil monkeys throws no light upon any of the hypotheses of transmutation.

Ordinary Meeting, Monday, May 4th, 1863.

Professor Tennant, F.G.S., President in the Chair.

The following gentleman was elected a Member of the Association:—Mr. Alexander Ramsay.

The following donations were announced:—

"*Abstract of Proceedings of the Geological Society.*" By the Society.

"*Catalogue of the Collection sent from the Island of Trinidad to the Exhibition of* 1862." By R. J. L. Guppy, Esq.

"*Geology of the neighbourhood of Leek.*" By Thomas Warlde, Esq., F.G.S.

"*Notices of Rocks and Fossils in the University Museum, Oxford.*" By the President.

"*Annual Address of the Cotteswold Club—Plates showing growth of Gryphæa incurva.*" By the Cotteswold Club.

"*Lectures on the Results of the Great Exhibition,* 1851." 2 vols. By the President.

The following papers were read:—

1st. "On some recent Marine Shells found in the excavations for railway-works at Preston." By Mr. Rofe, F.G.S.

The author commenced by stating that he brought the subject forward, not as a novelty, for some years since Mr. Gilbertson published the discovery of similar shells at Preston, when sinking a well, and every geologist knows, that not only in the British Isles but in most parts of the globe there are endless instances of recent shells being found elevated above the present sea-level, but because he considered that some inferences might fairly be drawn from these and other cases in Lancashire to show how comparatively recent has been the elevation of the Penine Chain in England, if indeed the elevation has not been going on gradually and is not even yet in progress.

Most of the shells* found appear to be identical with those common on the adjoining coast. They were discovered at two places about ¾ of a mile asunder; one locality being on the south end of the joint station of the London and North-Western and the Lancashire and Yorkshire Railway Companies at Preston, and about 65 feet above the mean level of the sea, and the other locality in a cutting for the Fleetwood and West Riding Railway, under Adelphi-street, and about 70 feet above the same level. In both cases they were found several feet below the surface of the ground in coarse sand, with small rolled pebbles, or perhaps, more properly speaking, in seams of fine gravel in the sand. In the first case, at the railway-station, the sand was covered by a bed of marl or clay, with boulders. In the other the sand came to the surface, but a little further north it is covered with the marl or clay, locally called "Till," being a portion of the Northern Drift.

The levels at which these shells were found appear to show clearly that the beds in which they occur must have been elevated from 60 to 70 feet at least since the existence of the present fauna. In a paper by Sir P. Egerton (see Proceedings of the Geological Society, vol. 2, p. 189) on a bed containing similar shells, found at "the Willington," in Cheshire, and not far from the Mersey, he states as the result of his research, that an alteration of the relative levels of sea and land to the extent of 70 feet has taken place since their deposition—a result closely in accordance with that shown at Preston, near the Ribble.

There are, however, many observations which prove an elevation during the same period very far greater than what is here named. On the coast of Wales sea-shells were found by Mr. Trimmer 1392 feet above the sea; and another instance, recently published by Mr. Binney of Manchester, who, at a meeting of the Manchester Philosophical Society, on the 2nd of December last, stated that Mr. Bateman had drawn his attention to the occurrence of the common cockspur shell (that found most abundantly at Preston),

* The shells exhibited were Astarte elliptica, Astarte compressa, Tellina solidula, Cardium edule, Littorina littorea, Turritella communis, Trophon clathratus, Murex erinaceus, Fusus antiquus (probably), and Nassa incrassata.—The names are kindly supplied by S. P. Woodward, Esq.

at the Corporation Waterworks, near Mottram. Mr. Binney went to the reservoir and there found other shells similar to those found at Preston. The locality where these are found is fully fifty miles in a straight line from the sea, and 568 feet above its level. Mr. John Taylor has also found recent marine shells in the sands at Bredbury and Hyde, and Mr. Prestwich on the Buxton Road, about 3 miles from Macclesfield. But Mr. Binney observes, that those he found near Mottram were the first which had been observed in the deep valleys running up into the sides of the Penine Chain.

The shells found by Mr. Binney, corresponding with those from Preston would, in both cases, probably be washed on to the shore; so that if the relative levels of the two places were the same as they now are, the land at Preston must have been covered with 500 feet of sea when that at Mottram first emerged. But this supposition is not essential, indeed it is more probable that the then coast was indented by deep bays or fiords, running up into what is now the Penine Chain, but then only partially raised above the sea-level, on the shores of which the shells were deposited. The force which elevated the Penine Chain acting probably in its centre, that part would be raised before the more distant parts were affected and would continue to rise more and more as the elevating force acted. Sir Charles Lyell, in his work on the "Antiquity of Man," mentions a somewhat similar case to that here supposed, at page 348. He says, "At Altenfiord, in Finmark, between lat. 70 and 71 N., an ancient water-level, indicated by a sandy deposit, forming a terrace, and by marks of the erosion of waves, can be followed for 30 miles from south to north along the borders of a fiord rising gradually from a height of 85 feet to 220 feet above the sea, or at the rate of about 4 feet in a mile."

The question wished to be raised by this paper was stated to be, whether the relative levels have remained the same, or whether the upheaval of the parts most distant from the sea has not been continued even since the elevation of that nearer the sea, that is to say, that Mottram has been further elevated since Preston emerged, and, indeed, whether that process may not be going on even in our own times.

The author again referred to Sir Charles Lyell's work, above quoted, to show that he was then starting no new heresy. At page 51 Sir Charles Lyell states, that "the emergence (of the Clyde Valley) appears to have taken place gradually and by intermittent movements, for Mr. Buchanan describes several narrow terraces one above the other on the site of the city (Glasgow) itself, with steep intervening slopes composed of the laminated estuary formation. * * * Until lately, when attempts were made to estimate the probable antiquity of such changes of level, it was confidently assumed, as a safe starting point, that no alteration had occurred in the relative level of land and sea, in the central district of Scotland since the construction of the Wall of Antonine. * * * But Mr. Geikie has lately shown that a depression of 25 feet on the Forth would not lay the eastern extremity of the wall at Carriden under water" * * * and the western end, on an eminence called Chapel Hill, the foot of which "is estimated to be 25 to 27 feet above high water-mark. * * * Antiquaries have sometimes wondered that the Romans did not carry the Wall further west, but Mr. Geikie now suggests, in explanation, that all the low lands 16 or 17 centuries ago were washed by the tides at high water. * * * There is also a raised beach with marine shells 25 feet high at Leith, as well as at other places on the Firth of Forth." And at page 55 Sir Charles says, "On a review of the whole evidence, Geological and Archæological, offered by the Scottish coast-line, we may conclude that the last upheaval of 25 feet took place not only since the first human population settled in the island but * * * there seems even a strong presumption in favour of the opinion that the date of the elevation may have been subsequent to the Roman occupation."

With such an authority there can be no presumption in assuming from the following considerations, that it is at least possible, if not probable, that a similar rise has taken place in Lancashire during the same period, and, probably, to about the same extent. At Preston, and on the west side of it, there does not appear to be any reason to suppose that there has been any rise of the land during the period last referred to; possibly the reverse may be the case, as there are undoubted evidences of a submarine forest on the coast between the mouths of the Ribble and the Mersey, but that might be, and most probably was, submerged before the Roman occupation. However, there is no doubt that the Romans had a station at Naze Point, at the mouth of the Ribble, and another on Walton Flats, near Preston, both of which are now very little above high-water-mark, so that it is clear that they cannot have been raised since that time. But about twelve miles (following the course of the river) above the latter point, there is another Roman station, Ribchester, where remains of anchors and other materials used in navigation or boat-building have been found. Between Preston and Ribchester there are now several places where the rock crops out across the bed of the river, so as to render it quite impossible for a boat of any size to navigate it, and some local historians seeing this difficulty have considered that the anchors, &c. found at the latter place could only have been used for the ferry-boat there. But it is scarcely likely that the Romans would have forged anchors for ferry-boats when mooring-posts would have been so far readier to use and better for the purpose, and the quantity of what may be called naval stores discovered was so great as to give the name of Anchor-hill to the place where they were found—a quantity which could scarcely be brought together for a ferry over so shallow a river as the Ribble now is. The fall of the present bed of the river to Preston is also so great that it scarcely could be navigable under ordinary circumstances; but if the interior of the country generally has been raised, and the bed of the river has been thus rendered more inclined since the Roman period, as Sir Charles Lyell sees reason to think that part at least of Scotland has risen since that time, this difficulty might be overcome, and the river may have then been navigable.

There is, in addition, an intermediate archæological notice which gives greater weight to this opinion. Leland, who visited Ribchester in the time of Henry VIII., states that "The tide ebbeth and floweth in Ribbel most commonly more than half-way up between Preston and Ribchester, and at ragis of spring-tide much further." At the present time, however, the ordinary spring-tide rises only to the reach under Walton Church, about a mile above Preston, and never even at "ragis of tide," above the rapids at Cuerdale, a little more than half a mile higher, and nearly (by the river) ten miles below Ribchester; so that some considerable change has taken place even since the time of Henry VIII.

It may be asked what has caused this rise of the land, and how has it been effected. This can, at present, only be answered by supposition. Dr. Forchhammer, in a paper (see Proceedings of Geological Society, vol. 2, p. 554) on some changes of level which have taken place during the historical period in Denmark, infers that the change of level on the Swedish, proceeds in a different proportion to that on the Danish shore, which he ascribes to the slight earthquakes so frequently felt in Sweden, but never observed in Denmark. And to the same cause, the supposed rise in Lancashire may with probability be attributed. In the ninety years from 1753 to 1843, six earthquakes in Lancashire have been recorded. One in 1777, observed by Dr. Henry, is stated to have been a smart shock, and that in 1843, was felt throughout and beyond Lancashire, and left proof of its effects, few only of which are recorded. Mr. Just, of Bury, Second Master of the Grammar School there, stated that his house was so much injured, and in such a manner as to indicate a decided change in the level of the foundation; and on the banks of the Ribble, at Red Scar, Mr. Cross, the day after the earthquake, found that his large equatorial telescope, which was mounted on a base of solid masonry, required complete readjustment; showing that the country at Red Scar had undergone not merely a movement which afterwards permitted things to resume their exact position, but that some permanent alteration had taken place.

In addition to these earthquakes, it is recorded that in December, 1774, the River Ribble stood still and became dry, excepting in some particular places for the space of five hours, and then began to flow again as usual; and again on the 8th of March, 1821, the River Ribble ceased to flow for three hours at the ford, where the boat goes over at Alston. These last events, though they do not prove much, add some weight to the supposition that an alteration in the relative level of the country may be taking place, as these stoppages in the flow of the river, in certain localities only, can scarcely be accounted for except by such a supposition.

The above are the earthquakes recorded during only ninety years;

how many slight shocks there may have been unrecorded cannot be said, nor how many may have been unrecorded and forgotten in the previous 1,500 or 1,600 years since the Romans occupied Ribchester. No doubt that slight shocks *may be* frequent, and pass unnoticed, because even the last at Preston was not noticed by some persons who were in the streets, though the motion was sufficient to ring the bells in some of the houses in that town.

2nd. "On the Geology of the neighbourhood of Croydon." By Mr. Bott.

3rd. "On a Geological Ramble to Maidstone and its neighbourhood." By Professor Tennant; which was followed by some remarks on the probable causes of the phenomena presented by a section across the Cretaceous and Wealden strata of Kent and Sussex, by the Secretary.

Ordinary Meeting, Monday, June 1st, 1863.

Professor Tennant, F.G.S., President, in the Chair.

The following gentleman was elected a member of the Association:—Mr. Edward Langdon.

The following donations were announced:—

"*Quarterly Journal of the Geological Society.*" By the Society.

"*Abstract of Proceedings of the Geological Society.*" By the Society.

"*Annual Address of the President to the Geological Society.*" By Professor Tennant.

"*Transactions of the Geological Society of Glasgow.*" By the Society.

The following papers were read:—

1st. "On Microscopic Geology," Note No. 1.* By Mr. W. Hislop, F.R.A.S., &c., Treasurer.

2nd. "On the Strata exposed by the Excavations for the Southern High Level Sewer Main Line." By Mr. A. Bott, F.G.S.

* Will be published with Note No. 2 in the next number of Proceedings.

London is situated in a valley, bounded on the north by Hampstead Hill, which rises about 430 feet above the Thames, and on the south by a range of hills, of which Norwood, the highest, is 353 feet above that level. This valley gives unmistakeable evidence of having been formed by denudation and erosion, for there is a sandy bed lying nearly horizontally, about 100 feet beneath the surface, at the top of Highgate and Hampstead Heath, and which occurs also very near the summit of Norwood Hill, but which is entirely wanting between. This is sufficiently conclusive evidence that this bed of sand, and many beneath it, were once connected; but have been denuded and eroded, by some great current running from west to east, and forming the valley of the Thames.

Also from the alluvial deposits in the lower parts of this valley, there is no doubt that the Thames, at one time, occupied a much wider space than that of its present bed, forming swamps and bogs of many miles in extent; and to this is attributable the exceedingly fertile character of Essex.

It is to drain this valley of its sewerage that these sewers are being constructed; but, while London will thus be benefited to a very great extent, we shall, on the other hand, lose a large amount of our surface-springs; and many of the wells at Walham Green, near Fulham, and other places, have entirely dried up owing to these works.

The remarks, which follow, have reference to the main line of the Southern High Level Sewer, commencing at Deptford Creek, and terminating at Clapham Common. The total length of the excavation is 5 miles 1850 feet, and the ground gradually rises from east to west; at Clapham being about 60 feet above the level of the Thames.

The strata passed through consist of: clay and gravels of post-pliocene date, the London clay, and the lower members of the eocene group, namely, the Woolwich beds.

Sections taken along the line of Excavation.

SECTION No. 1.—Deptford Broadway.

Made ground	6ft.
Loam and gravel	6ft.
Loam and sand	3ft. 6in.
	15ft. 6in. deep.

A mile further on we come to—

SECTION No. 2.—Queen's Road, Peckham.

Made ground	3ft.
Brown clay and sand	9ft.
Grey sandy clay	4ft.
Dark grey clay	13ft.
Woolwich clay (very shelly)	2ft.
	31ft.

SECTION No. 3 is half a mile further on in Eastwood's Brickfield, Peckham.

Mould	2ft. 6in.
Yellow clayey sand	11ft. 3in.
Yellow sandy clay	4ft.
Light brown clay, with a little sand	4ft.
	21ft. 9in.

SECTION No. 4.—Denman Road, Lyndhurst Road, Peckham.

Made ground	2ft.
Yellow clay (brick-earth)	2ft.
Sand and gravel	2ft.
Greenish mottled sandy clay	18ft. 6in.
Woolwich clay (very shelly)	3ft. 6in.
Clayey green sand with a few shells	5ft. 6in.
	33ft. 6in.

This is about a mile from Section No. 3, and half a mile from No. 5.

SECTION No. 5.—De Crespigny Park, Camberwell.

Made ground	2ft.
Brick earth-clay	7ft.
Sand, with a little gravel	6in.
Sandy clay	6ft.
Fine gravel, sand, and water	3ft.
Gravel	7ft. 9in.
Loamy yellow clay	1ft.
Blue London clay	3ft.
	30ft. 3in.

SECTION No. 6 is about half a mile further on; Lilford Road, Cold Harbour Lane.

Loamy gravel and sand	2ft.
Sand and gravel	3ft.
Coarse gravel and water	20ft.
	25ft.

About a mile's more walking brings us to—

SECTION No. 7.—Stockwell Green.

Made ground	2ft. 6in.
Coarse gravel	10ft.
Blue London clay	6ft.
	18ft. 6in.

After another half a mile we come to—

SECTION No. 8.—Stockwell Private Road.

Made ground	6in.
Mild yellow clay	9ft. 6in.
Strong yellow clay	16ft.
Blue clay	2ft.
	28ft.

These, with the exception of the made ground, all belong to the London clay.

SECTION No. 9 is at the end of the excavations.—Plough Inn, Clapham.

Made ground	2ft. 6in.
Light green sand..........	2ft. 6in.
Gravel	7ft.
Yellow clay	1ft.
Blue clay	12ft.
	25ft.

The last two mentioned strata are members of the London clay.

At Hanover Park, between sections 3 and 4, we have a small local bed very much resembling the Irish peats. About six feet below the surface, in this bed, were discovered a great quantity of mammalian remains—antlers of the Irish Elk, or Megaceros Hibernicus, horns most probably of a species of Bos, and many jaws and teeth of smaller mammals. Several of the latter are now in the possession of Mr. Richards, a member of this Society. There were also found here a pair of large tusks of Elephas, probably Elephas primigenius, in their natural position with regard to the lower jaw; as well as the lower jaw of an elephant, with the teeth on either side.

We then pass through, in all the sections, clays and gravels belonging to the drift-period; but which, as they contain no fossils, are of no particular interest.

The next deposit we come to is that of the London clay. It is cut through in sections 5, 7, 8, 9; while it is altogether wanting in sections 2 and 4, where we pass at once from the drift-deposits, or gravels, to the Woolwich beds. The fossils were found mostly at Clapham and Stockwell. They were of the usual character, such as Nautilus, Terebratulina, Natica, Nucula, Cardium, Lignite, &c.

The London clay is, as we need hardly remark, of decidedly marine origin; for though it contains remains of animals which lived on the land, these were borne down by the rivers, and commingled with those living in the seas; still, in a proportion, and in a manner which constitute the latter the great distinctive feature of the group, and clearly indicate the marine origin of the strata then and there accumulated.

It appears to have suffered denudation to a great extent, as also several beds above it, at the glacial period; and the only peculiarity about this, is that while the flints give evidence of the chalk having been denuded, I think I am right in saying, we find no London clay septaria amongst the gravel. So far, at all events, as my own personal experience goes, I have never seen or heard of any having been found in these beds; and this, I think, is worthy of notice, because the septaria seem hard enough to have resisted any amount of ice- or water-action; and the only question that suggests itself is, whether they had attained that degree of hardness and solidity, when they were washed out of the clay?

The third and last series we descend to is that of the Woolwich beds. They occurred at Camberwell, between sections 4 and 5, and were also cut into at sections 2 and 4. The strata consisted of greenish sandy clay, the paludina-band, clayey sands, and oyster-beds.

In the first no very perfect shells were found, but it contained Cyrenæ, mostly cuneiformis and cordata, in a very fragile and broken condition. The next, the paludina-band, is composed of a greyish clay, exceedingly hard and compact, and is capable, when ground up, of making a very good cement; indeed, it was made use of for that purpose by the contractors for the sewers.

The Paludinæ, from which the bed is named, occur in bands or belts about six inches apart, and form a perfect floor of shells of some miles in length. Between these bands very few shells are found, and those which do occur are mostly in a crushed condition. This bed is of fresh-water origin, and was formed in comparatively a lengthy period. We judge this from the compactness of the rock, and also from not finding any large stones or pebbles in it. There also appear to have been periods when the deposition was arrested; and these must have been also long, in order to allow the bed to become carpeted with these millions of Paludinæ. Amongst the shells we find teeth and bones of fish; the teeth resembling Lepidotus,—a species of fish nearly allied to the North American genus Lepidosteus.

It is a curious fact, that while in the hard conglomerate which we find at Dulwich there are a great many of the enamelled scales of these fish to be found, in this paludina-band, which is of more recent origin, we find no scales, at least of this hard, bony, polished character, but a good many teeth. I have in my collection some eight or nine; most of them are, however, very minute.

The periods interposed between the deposition of this clay were not of equal length, as we have evidence of the bands of Paludinæ in some cases being very thick of shells, and frequently the next band above them contains but few specimens, as if this period was not sufficiently long for them to multiply to such an extent as before.

Another peculiarity of this bed is, that while at Peckham Rye comparatively few of the opercula of the Paludinæ are to be found, at Camberwell they occur in great numbers. The mollusca appear to have all died before a fresh deposition of the strata took place; for the shells are mostly filled with the clay, and in no case have I found a shell with the operculum attached, and I think only one in which there was molluscite. Also the opercula are not found in the same line as the shells, but generally in a layer about half an inch above each band of shells; as if the creatures had died from some chemical change in the water, their bodies had decomposed, and the opercula had floated away and had been deposited elsewhere. Though abounding in shells, this bed contains only four species: Paludina lenta, and probably fluviorum: Pitharella Rickmani, Unio, and occasionally, though very rarely, Cerithium.

Of the Pitharella Rickmani I am not at all satisfied that there are not two varieties; indeed, two specimens I possess show such a marked difference in general appearance, that I feel almost certain that they are distinct species; the one is much rounder at the shoulder than the other, and has a more conical spire. I submitted them to Mr. Mackie, and they passed from him, I believe, to Mr. Edwards; but no satisfactory conclusion has been arrived at, and I am as uncertain as ever as to whether my inference is correct.

I have also found from this bed some beetles' wing-cases, but they are very rare and minute. Mr. Evans has also obtained some from the same bed.

The remark, as to paucity of species applies with almost equal force to the rest of the Woolwich series, and Mr. Prestwich gives us this explanation of it. He says, in a little work of his called "The ground beneath us," "It is a peculiar feature of a fresh-water fauna, that although fossils may abound,—may form whole beds,—yet they consist of very few sorts; the individuals are in thousands, but the species are very few."

Passing downwards we next come to a bed of clayey sands of a hardish character, but which rapidly decomposes by exposure to the weather. In it we find the following fossils: Cyrena cuneiformis, Cyrena cordata, Cyrena deperdita, Cerithium funatum, Melanopsis brevis, Neritina, and lignite occasionally containing Teredina. This stratum must have been formed under conditions entirely different from the bed above; the rock, with its associated fossils, giving us pretty clear evidence of having been formed in an estuary.

The oyster-bed contains a great number of Calyptræa trochiformis, Cerithium funatum, and Arca Cailliaudi. The oysters consist of several varieties, namely: Ostræa tenera, pulchra, bellovacina, edulis.

Such, then, are the strata through which the main line of the Southern High Level Sewer has passed; and I will only, in conclusion, offer you a brief retrospect of the probable changes that have taken place in this locality.

First, then, there is the marine deposit of the oyster-bed, which, from the quantity it contains, must have taken some time to accumulate.

Second. We have the estuarine clayey sands containing the Cyrenæ.

Third. The fresh-water stratum of that hard, rocky, compact clay in which we find the Paludinæ.

Fourth. A marine formation—the London clay—which mostly lies upon a shell-rock and pebbles (commonly called the oyster-shell rock), which is its basement-bed.

Fifth. We have several changes which are not chronicled here, or, if they have been, have shared the fate of part of the London clay, and have been denuded by that last agent, the iceberg.

We can thus easily trace six great mutations which have occurred since the deposition of the Thanet sands, which we find capping the Chalk at Lewisham and Charlton.

And when we think that the only traces of these changes are a few feet of strata, we cannot help feeling—even if we allow a greater intensity of action in the earlier period of the deposition of the stratified rocks—how vast an amount of time must have elapsed since water first played its part in the construction of our globe.

Ordinary Meeting, Monday, July 6th, 1863.

Professor Tennant, F.G.S., President, in the Chair.

The following gentleman was elected a member of the Association :—William Lester, Esq.

The following donations were announced :—

"*Abstract of Proceedings of the Geological Society of London.*" By the Society.

"*Proceedings of the Berwickshire Naturalists' Club.*" By the Club.

The following papers were then read :—

1st. "A Report of the Visit to the Dudley Geological Society's Anniversary Meeting, by the President and other members of this Association, held at Dudley, May 27-28, 1863." By Christr. Thos. Richardson, M.D., Cantab.

The report contained a general description of the prominent features of geological interest in the neighbourhood of Dudley, and described the several advantages and opportunities it afforded for study, to both the early and advanced student, of several of the great and characteristic phenomena recognised as causes, effects, and agencies by geological science.

The proceedings of the meeting were briefly detailed, consisting chiefly of the delivery of the annual address by S. H. Blackwell, F.G.S., in which a most able and comprehensive review was entered upon of the progress of geological science within the last 20 years, particularly with reference to the changes in nomenclature and classification, physical and practical geology and palæontology, and the recent evidence pertaining to the history of the antiquity of man.

A short address was also given by Professor Tennant, F.G.S., on "The Connection and Relation of Mineralogy and Geology."

Visits were likewise made to some points of interest in the neighbourhood, at which full descriptions were given of their characteristic features by some of the local geologists conversant with them.

The two chief localities were those known as the Castle and Wren's Nest Hills, eminences of about 700 feet in height, constituted by the upheaval and protrusion of the Ludlow and Wenlock Limestones of the Upper Silurian rocks, through the local series of the coal-measures. These beds of limestone, separated by shales, have been long worked, and extracted for economic purposes in the manufacture of iron, leaving behind most extensive and curious caverns, presenting many highly instructive illustrations of important geological events.

By permission, the members of the Association were witnesses of the interesting process of smelting and casting iron on a large scale into its first marketable form of pigs from the rough ore, and the combustion of iron in atmospheric air, both of which processes were, with all connected with them, most ably detailed by the proprietor.

A visit was also made to a neighbouring coal-pit, into which a large party descended. The seam being worked was that known locally as the Thick Coal or Ten-yard Seam, where a full detail was kindly given by one of the gentlemen associated in the work, upon all the points of interest; and in the progress through the mine attention was called to the extent, limits, and variations of the several beds composing the great seam; its cracks, fissures, faults, and subsidences; the pervasion and intrusion of veins and masses of basalt and greenstone, and their metamorphosing action upon the coal in contact with them; the mode of working the coal visibly illustrated; and the dangers arising from, and the situations in which the two noxious gases choke- and fire-damp become generated, and the inflammable nature of the latter shown by the ignition and explosion of a quantity purposely allowed to accumulate.

The author concluded by mentioning the kind reception and welcome given to the deputation by the Dudley Society, the gratification the visit had afforded them; and the hope of a repetition of the visit and the establishment of a close and intimate connection between the two societies established.

2nd. "On the Geological Distribution of the 'Pitharella Rickmani.'" By Mr. C. Evans.

In this paper Mr. Evans, after noticing the discovery of the first specimen of Pitharella, by Mr. Edmund Jones, in Cow Lane, Peckham, observed that during the construction of the Efra branch of the Southern High Level Sewer, near St. Mary's Church, Peckham, numerous specimens of this shell were found in the Paludina-band (described by Mr. Rickman in No. 6 of our Proceedings), chiefly in the form of casts. At the tunnel at Dulwich, on the same line of sewer, blocks of sandstone abounding with fossils were exposed. On a few well preserved specimens of the Pitharella being met with in the latter stone, Mr. F. E. Edwards published a description with figures of the shell in the Geologist for June, 1860, and then assigned to it the above generic and specific names. It was considered by that gentleman to be allied to the Auriculidæ, Achatinidæ, or Limnæidæ.

At the meeting of this Association, held on the 4th March, 1861, Mr. Pickering questioned the correctness of Mr. Edwards's conclusion, and expressed his opinion that the Pitharella was more closely allied to Ampullaria, Paludina, Melania, and Paludomus. As these latter shells belong to the great group of Operculated Mollusca, Mr. Evans submitted to Mr. Pickering, and afterwards directed attention in the Geologist for June, 1861, to a single specimen of an elongated operculum, which he had obtained from the Paludina-band at Peckham, which appeared to him to be fitted rather for the elongated aperture of Pitharella than to the rounded mouth of the Paludinæ.

Mr. Bott also, dwelling more particularly on the varying proportions of the spire, has suggested that the specimens met with in the Paludina-band should possibly be grouped as two distinct species.

For the correct determination of the various questions which have been from time to time raised on this subject, it is desirable that due consideration should be given to the mineral characters of the beds in which the shells occur, and to the fossils with which they are usually associated.

The Peckham Paludina-band may be described as an indurated marl or calcareous clay, and was probably deposited as fine silt at the bottom of a stream or pond. It was a purely freshwater deposit, as specimens of Paludina may be observed scattered sparingly throughout. At occasional intervals vast numbers of these shells were spread over the surface, after which the former condition of a muddy deposition appears to have recurred. It is in these bands that numerous specimens of Pitharella have been met with, and when so preserved the spires of the different specimens are found to vary greatly as to the amount of elevation. In this same bed have been found a Unio, numerous opercula resembling that of Paludina, a more elongated form of operculum noticed above, also scales and a few teeth of Fishes, Chelonian remains, and, rarely, leaves, and the elytra of Coleoptera.

The same band was again well seen in the open cutting at East Dulwich, which was commenced after the tunnel was completed. From this spot numerous specimens of the Paludina were obtained, and a few casts of Pitharella, resembling in form those from Peckham. This band was associated with, but distinct from, beds abounding with Cyrena, together with a layer of oyster-shells, and it occupied the same relative position in the section as the Paludina-band at Peckham. Below was a deposit of woody clays and greenish sands, and near the bottom of the excavation large masses of the hard shelly sandstone or "Dulwich Rock," were met with.

There appeared to be two varieties of this latter stone, differing somewhat the one from the other in mineral character and fossil contents, although both varieties were occasionally met with in the same block. The most common of these two varieties may be described as consisting of a crystalline sandstone, containing patches or small nodules of a brown, green, or red earthy material, occasionally indurated, and abounding with several species of Cyrena (including C. Dulwichiensis), mostly as single valves, but occasionally with the valves united and closed; with these the scales of a ganoid fish (Lepidotus or Lepidosteus) were present in considerable numbers, with occasionally wood, bone of the Trionyx or River-tortoise and Mammalian bones and teeth. The other variety, consisting also of crystalline sandstone, contained fewer Cyrenæ, although they are still the most abundant fossils, and in addition to these Mr. Evans found fine double specimens of Cyrena Dulwichiensis, together with Melania inquinata, Cerithium funatum, Melanopsis buccinoides, Neritina globulus, N. consobrina, Rissoa or Hydrobia, Unio, Ostrea, &c. Many samples of this variety contain masses of wood of considerable size, often bored by fine specimens of Teredo and Teredina. Few Pitharellas were to be found in the first of the above varieties, the most favourable lumps being those that contained fewer Cyrenæ and much wood. In one small block which contained a large mass of wood with Teredo, were found as many as 22 specimens of the Pitharella, mostly of small size and with thin shells.

Mr. Evans then endeavoured, from a consideration of the habits of the recent analogues of the most abundant fossils, to arrive at some conclusion as to the condition under which these various deposits were formed, and suggested, without forming any very decided opinion, that these beds were fitted rather to serve as the habitat of a shell allied to the Ampullaridæ than to the more purely freshwater family of Limnæidæ.

He also suggested, in conclusion, that a change of character of the river-bed, or a slight change of climate might have given rise to variations in the general proportions of the shell.*

* On the occasion when the above paper was read, Mr. Bott exhibited some

3rd. "Observations on Ammonites, and on the Natural History of the Tribe of Molluscous Animals to which these remarkable extinct shells are supposed to belong." By E. Charlesworth, F.G.S.

The following account of the visit of the Association to Herne Bay and Reculver, has been prepared by Mr. George Dowker, who directed the excursion :—

About 30 of the members assembled at Herne Bay on June 26th, 1863, and proceeded in conveyances to Reculver, passing on their way the various sections exhibited near the bridge-crossings of the Herne Bay and Margate Railway (now in course of construction).

The first of these sections (a short distance from the Bay) shows, in a deep cutting, the London clay, capped by an ochreous clay and gravel. The next crossing, near May-street, towards Hillborough, exhibits a section in the pebbly gravel-beds similar to those capping the cliffs near Bishopstone, it being probable that the flint implements found near Reculver belong to this deposit. It is a point of considerable interest to determine its probable geological date. If I might venture a conclusion on this most difficult subject, I should place these deposits in the third subaerial epoch of the glacial period of Professor King's Table.† These deposits are supposed to be of fresh-water origin, the river-beds of tributaries of the Thames, before the sea encroached on its present domain.

On alighting at Reculver we proceeded to view the church and Roman Castrum. Reculver, the ancient Regulbium, was a military station of great importance in the time of the Romans. Reculver and Richborough were the Roman stations constituting the Rutupiæ, and were then at the entrance to the estuary, which reached from Reculver to Pegwell Bay, constituting the western boundary of the Isle of Thanet.

I believe the Geologists' Association could not have chosen a spot containing more instruction in a geological and historical point of view. It is here that archæology and geology meet, stationed in this Roman Castrum, whose timeworn walls are crumbling to

fossils from the Dulwich rock, comprising, in addition to some fine Pitharellas, a specimen of Bulimus ellipticus, and Mammalian remains.

† See Geologist for May, 1863.

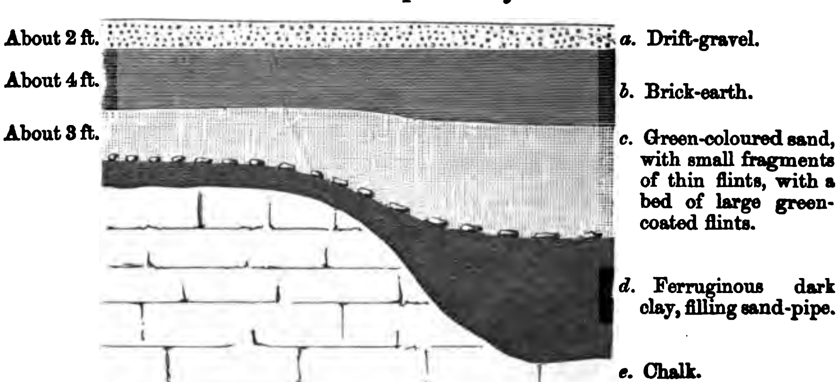
decay. Beneath these old church-towers, the emblems of a state and power now passed away, without a record of the past, save the rude architecture of the Roman or early Saxon,* the burial-place of kings, whose whitened bones protruding from the cliff mark how the clamorous waves have violated the sacred precincts of the dead. Here, too, we tread upon a soil once held by races of pre-historic man, whose rude flint implements are found upon the shore. The mighty deep is gaining on the land, and acting over again her ancient part in forming fresh deposits from the wrecked *débris* of former ages.

Leland speaks of Reculver in his time as "sore decayed, and distant half a mile from the sea." In 1780 the north wall of the Roman Castrum, which was distant 80 yards from the church, had been lately overthrown by the sea, and the angle of the tower to the north was distant 50 yards from the border of the precipice. At the present time (1863) the tower to the north is close to the edge of the cliff, which is preserved by numerous groins erected by the Trinity House.

It was shown by Mr. Masters that numerous semi-fossil trunks of trees had been found in the neighbouring marshes, and were, in some cases, large enough to be used for building-purposes.

Reculver was chosen by King Ethelbert as his place of residence, and he was buried there about the year 616.

Section in Chalk-pit North of Chislet.



* Richborough, Reculver, and Lyme. G. Roach Smith.

From this elevated point of view the chalk-cliff of Birchington can be seen. The chalk again rises near Chislet, where a section to be seen in a chalk-pit on the right hand side of the road north of the church presents features of much interest, which will be best understood from the accompanying sketch.

If *c* in the figure be true bedded Thanet sand, with the usual flints at the base, it seems difficult to account for the yellow clay filling the pipe beneath, unless we suppose it to have some connection with the upper beds not here shown. On the other side of the road a section of drift over the chalk is seen, which has been described by Mr. Prestwich in the Geological Journal, No. 42, page 111.

The chalk of Birchington has not those regular layers of stratified flints so often seen in the upper chalk; thin tabular flints often occur in a diagonal, or nearly vertical, position at places. The chalk appears much denuded and broken up, the surface being strewn with green coated flints, derived from the base of the Thanet sands. On the other hand, the chalk of Ramsgate and Pegwell presents the well known beds of flints every three or four feet apart. Richborough Castle, almost to be seen from this point, is situated upon a portion of the Woolwich beds, having the Thanet sands at its base.

Descending from the churchyard at Reculver we find the cliff composed almost entirely of that portion of the Lower London Tertiaries, called by Mr. Prestwich "the Thanet Sands," composed essentially of a yellow and greenish quartzose sand, becoming more argillaceous as we descend; and having interspersed at its upper part (here at the base of the cliff) tabular concretionary blocks of indurated sandstone, these blocks generally resting upon a very fossiliferous deposit, and often with shells of the genus Cyprina, in great abundance. The shells of this deposit are very friable, owing to the porous nature of the sands they are embedded in, and are, in many places, found chiefly as casts. These Thanet sands extend downwards to the depth of 90 to 100 feet, as I have proved in a well sunk at Stourmouth.*

* See Geologist, 1861, p. 213.

Mr. Prestwich, to whom every geologist must be deeply indebted for his knowledge of the lower tertiaries, has so ably described the sections exhibited here that I cannot do better than quote his general conclusions on these interesting formations:—"The Thanet sands are the lowest of the eocene strata of England, and Mr. Prestwich has shown their connection with the Lower Landenian beds of Belgium, described by Sir Charles Lyell. The latter are characterized by a green sand and sandstone, termed glauconite. The connecting link between the cretaceous and tertiary strata is wanting in England, and is represented on the continent by the Mæstrich beds. The chalk appears to have been extensively denuded previous to the deposition of the lower eocene beds."

Passing along the cliff, towards Herne Bay, we find this bed (the Thanet sands) gradually dip, until at Bishopstone it is lost in the base of the cliff.

Immediately over this deposit is another (here very similar in lithological character where the two meet). It is the middle of the lower or eocene London tertiaries, termed the Woolwich beds, from being largely developed at Woolwich, where they form strata of considerable thickness, consisting of clay, sands, and pebble-beds. Near Herne Bay the pebbles are, for the most part, wanting, the beds being composed almost entirely of a quartzose ochreous sand, at parts inclining to ferruginous, and in the lower part much mixed with a green sand. Near Woolwich this series is distinguished by a mixture of marine and freshwater shells. Among the latter Cyrena cuneiformis is very common. Here it assumes more of a marine character; traced in a westerly direction from Herne Bay this deposit assumes a more and more freshwater character.

Over this stratum we meet with another deposit, consisting of light-coloured sands, with concretionary masses of red sand, containing much iron, and at its lower part thin pebble-beds. I am not quite sure if the thin pebble-bed between this and the Woolwich beds should belong to the upper or lower series. This deposit is termed by Mr. Prestwich the basement-bed of the London clay. Near Canterbury parts of these beds have been quarried for smelting-purposes; and it is not uncommon to find "colliers" ballasting back to the north with this iron.

Before reaching Bishopstone the London clay proper has made its appearance over this light-coloured basement-bed, with which it contrasts greatly in colour and appearance; and from this point the lower beds dip under towards Herne Bay, where the London clay forms the entire cliff.

Owing to the great contrasts of colour and difference of the strata forming these cliffs, they present a most picturesque appearance. The lower sandy beds fall to the waves only from being undermined, and present a nearly perpendicular face, the concretionary masses of sandstone forming a pavement to the beach. The London clay, on the other hand, is constantly slipping down, and presents an irregular inclined plane. See Fig. 2.

The London clay this side of Herne Bay is not very fossiliferous, but abounds in selenite.

I have made little mention of the fossils to be found here, but the collector must possess much patience if he hopes to transport the shells from these beds to his cabinet. The Thanet Sands abound with fossils, but in these will be found few species—Cyprina Morrisii, being by far the most common in the whole series; Thracia oblata, Panopæa, Cytherea orbicularis. These are the most common. In the Woolwich beds Corbula, Dentalium, Cucullæa, and Cyprina being common. Large masses of silicified wood, often bored by Teredo, are found in this and the Thanet Sands, some of which was procured from Reculver by the excursionists. In the Basement-bed many fossils are found in casts in the concreted masses of iron-rust and pebbles.

For a more detailed account of these deposits, I must refer my reader to the excellent papers on the Thanet Sands and Woolwich beds by Mr. Prestwich, in the Geological Society's Journal. I will conclude this paper with a description of the drawings annexed, which, being not mere diagrams, but careful drawings taken on the spot, will give you a better idea of the appearance of these cliffs than any description, and will, I hope, guide the tourist in his search of the geological sections of this cliff.

Fig. 1 represents the cliff about one mile west of Reculver, the towers of which are seen in the distance. On the top of the cliff at *a* we have a drift-gravel, from which, most probably, the flint implements found here have been derived. Beneath this, *b* represents the basement-bed, but little shown, however, but containing, beside pebbles, some tabular blocks of sandstone. Then, at *c* the Woolwich beds, composed here almost entirely of light-coloured sand, and forming the most part of the cliff. The junction of this bed with the Thanet Sands at *d* is very obscure; and, as a general rule in East Kent, I should say noñe but the practised eye could detect the difference. At the base of the cliff are seen large masses of argillaceous sand-blocks, exceeding rich in fossil shells; these belong to the Thanet Sands. They here resist the action of the waves better than the upper sand, which presents a perpendicular surface till undermined by the waves, when large masses fall, and the more sandy portions are speedily washed away. Quite at the base of the cliff are seen several sandstone blocks, derived from the Basement bed, *b*.

Fig. 2 is a drawing of the sections shown at the Oldhaven Gap, looking towards Herne Bay. The top of the cliff is here composed of gravel-drift, marked *a*. The junction of this with the London clay is not seen in the Gap, probably from some drift and disturbance; but immediately beyond the dark London clay is distinctly seen capping the light sands of the Basement-bed, *c*. The London clay also extends considerably eastward of the Gap towards Reculver. The characteristics of the Basement-bed are here beautifully shown. The upper part of the section in the foreground is composed of this deposit. The light and almost pure sand is drifted by the wind, and at the corner leaves the ironstone blocks and concretionary masses in relief. The band of pebbles is likewise here distinctly marked, and forms the boundary-line between the Basement-bed and the Woolwich beds *d*, which latter compose the rest of the cliff.

Ordinary Meeting, Monday, November 3rd, 1863.

Professor Tennant, F.G.S., President, in the Chair.

The following donations were announced:—

"*Smithsonian Report of* 1861."

Fig. 1.

Cliff about one mile west of Reculver.

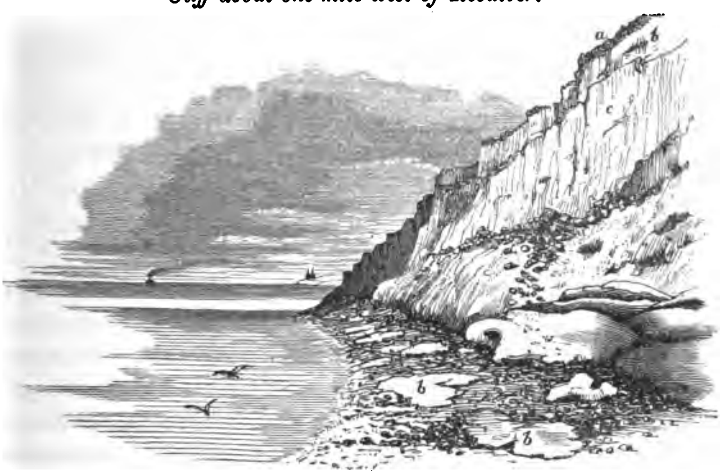


Fig. 2.

Cliff at Oldhaven Gap, looking towards Herne Bay.

"*Quarterly Journal of the Geological Society.*" By the Society.

"*Annual Report of the Royal Polytechnic Society.*" By the Society.

"*Guide to Excursion to Canobie, Liddesdale, and Keilder Castle.*" By the Institute of Mining Engineers, Newcastle.

"*Tyneside Naturalists' Field-Club Proceedings,* 1863." By the Club.

"*The Lignites and Clays of Bovey-Tracey, Devon.*" By W. Pengelly, Esq., F.R.S., F.G.S.

"*The Structure of Lavas which have consolidated on Steep Slopes.*" (Sir Chas. Lyell). By Jas. Johnson, Esq.

The following papers were read:—

1st. "On Fossil Elephants." By Mr. Carter Blake, F.G.S.

2nd. "On Fossils from the Railway-cuttings in the Vicinity of London." By Mr. C. Evans.

My object on the present occasion is to direct the attention of the Association to localities which for a limited period will probably afford much instruction, both to beginners and more advanced geologists, and bring to light many facts of great interest.

The town of Sevenoaks is situated near the top of the high ridge which throughout the greater part of Kent separates the valley occupied by the Gault from that composed of the Weald Clay.

At Riverhill, about two miles south of the town, the hill ends in a steep escarpment, affording a fine prospect over the Weald of Kent as far as the Forest Ridge.

A tunnel on the new line of railway from Lewisham to Tunbridge (South Eastern Railway), now being driven under Riverhill, will be about two miles long, and is being constructed by means of 15 shafts. The south-east entrance will be at a distance of about half a mile south of the escarpment of the hill.

From lane-sections in the neighbourhood it can be observed that the general inclination of the beds here is at a slight angle to the north. The general character of the beds passed through may be well seen by examining the materials thrown out at the various shafts. These shafts are numbered from the south end.

The shafts numbered 1, 2, 3, 4, and 5 are all on the comparatively low ground at the foot of Riverhill. The first four show the Wealden beds, consisting of blue and greenish clays with more indurated portions, and large masses of limestone, which probably form bands of stone. The fossils are abundant, consisting principally of Paludina, Cyrena, Unio, Cyprides, and fish-remains, and are all of freshwater forms. At No. 5, immediately below the escarpment of the hill, the beds become of a more brackish water character, as, together with Cyrena, Cerithium occurs in considerable numbers.

At the shaft No. 6, at the top of the hill, the works pass through a similar bed of clay, but here and at many of the shafts to the north, much water has been met with. The lowest bed reached appears to be the Weald Clay, which is evidently retentive of water; but above this is a bed of dark clayey sand, which is raised in a semi-fluid condition. This bed is succeeded by the stony beds of the Kentish Rag series.

Those portions of the sandy bed which are tolerably firm contain numerous marine fossils, well preserved, but in a very tender condition. A small Corbula (C. striatula) is the most abundant fossil, together with this are found Arca Raulini, Perna Mulleti, and many other species.

The position of this bed and the group of organic remains which it contains, clearly show that it is the equivalent of those junction-beds between the Weald Clay and the Lower Greensand, to which Mr. Godwin-Austen has applied the name of the Neocomian division, and which are characterised by the presence of Perna Mulleti.

The exposure of the Neocomian bed at this locality is a fact of great interest, since, though well seen on the coast of the Isle of Wight, at Atherfield and Sandown Bay, it has been only clearly observed at intervals in inland districts. (See Proceedings of Geological Society, vol. 4; Mem. Geo. Surv. Isle of Wight, and Geologist, 1862.)

The Kentish Rag division, which succeeds, resembles the beds at Hythe and Maidstone, consisting of layers of hard stone, somewhat calcareous, with a softer sandstone with green particles intervening. The general character of the stratification may be seen in the cutting near the north-western end of the tunnel. Many of the blocks of stone, chiefly of the softer variety or "hassock," are fossiliferous, but the fossils are mostly in the form of casts. Those belonging to the oyster family and to the Brachiopoda are well preserved. The Kentish Rag division can be well seen in the open cuttings, which extend from the mouth of the tunnel, as far as the road from Sevenoaks to Riverhead. The most northerly cutting has apparently passed through the top of an anticlinal axis or saddle, the beds on the one side dipping to the south-east, and on the other to the north-west. On the surface of some of the blocks of stone there are seen minute black pebbles.

After crossing the Riverhead Road, the line will pass over lower ground, part of which is wet and marshy, by means of a high embankment, formed of the *débris* from these Ragstone cuttings, and numerous specimens of the fossils of this division may be here obtained.

The nature of the material forming the marshy ground is not clearly seen, but from the heaps thrown out in digging foundations for bridges, it appears to consist of a light-coloured, clayey sand. Another hill intervenes between this valley (which is of small extent) and the broad valley of the Gault. The cutting through this hill shows it to consist entirely of yellow and ferruginous sands, with little, if any, stone. In the neighbourhood, a considerable quantity of pebbly ironstone is obtained from these beds, where it occurs as irregular layers and veins. I have observed no fossils in these sands.

After crossing the valley of the Gault, near Riverhead, the railway will enter on the Chalk district of the North Downs, at Madams Court Hill, under which it will pass by means of a tunnel, a mile-and-a-half long. This tunnel has just been commenced. I should observe, that there is no exposure of the Upper Greensand on the surface in this district. It may possibly be observed in the slight cuttings which will be formed in the undulating ground at the foot of Madams Court Hill.

Another tunnel through the Chalk is being made near Farnborough, in Kent.

Near Farnborough, the line will enter on the Tertiary district, and a very interesting deposit is now being tunnelled through, about a mile north of the Bickley Station, on the Mid-Kent Railway.

This deposit forms part of the Lower Eocene, or Lower London

Tertiary Group, and probably occupies a position near the top of the Woolwich series of beds, formerly known as the Plastic clay. The subsoil of the country, in the neighbourhood of Bromley, consists of thick beds of black flint pebbles in sand, forming vast heaps of shingle, well seen in the deep railway-cuttings near the Bromley and Bickley Stations. These pebble-beds are occasionally concreted, and then form the conglomerate long known as the Bromley Oyster-rock. In the cuttings of the new railway at Elmstead Lane, the sands and shingle-beds are well seen, while the adjacent tunnel passes through a light-coloured sand, with round flint pebbles, and also a concreted band of hard conglomerate. Both the sand and the stone contain numerous fossils of the Woolwich series, together with some new species. A very fine species of Pectunculus is extremely abundant.

Between this tunnel and Lewisham, the cuttings on this line, and also on the Dartford branch, will principally pass through the sands and shelly clays of the Woolwich series, where ordinary specimens of the fossils of this period may be obtained.

Between Mottingham near Eltham, and Lewisham, there are cuttings through a brown clay, with septaria, which is evidently a portion of the London clay.

Another line is at present being made, the works of which will afford to collectors specimens of London clay fossils of considerable interest. On the line of railway which is to extend from Peckham to the Crystal Palace, a tunnel is being formed under Dulwich Wood, at a depth of above 100 feet from the top of the hill on which the Palace stands. This tunnel passes through the dark London clay with septaria, some portions of the bed being slightly sandy. The fossils closely resemble, both in specific character and in their state of preservation, those which were obtained in great abundance at the time of the construction of the road at Highgate Archway.

We have also at present an opportunity of obtaining specimens of the fossils of the "Highgate zone," in the neighbourhood of the typical locality, as a railway has just been commenced which is to proceed from Holloway to Edgware. This line will cut through the ridge between Highgate and Crouch End, and a tunnel is being driven under the Muswell Hill road, near the Woodman Tavern. The fossils from this tunnel resemble those from Dulwich Wood, and also those from the Archway beds. This line will also pass through the high ground at the back of East End, Finchley, but the works in this part have not yet been begun. As a great part of the country in this neighbourhood is covered with the Northern Drift, it is probable that drifted fossils of the older formations, and interesting sections of the glacial formation, will be brought to light.

The examination of the geological details of the various undertakings, now being carried out in the neighbourhood of London, is a work for which the Geologists' Association is well fitted. If, from time to time, the members were either singly or in company to visit these various works, were to note any facts of interest that might be brought to light, and were to collect, and carefully preserve any fossils they might meet with, and, finally, on the completion of the undertakings, were to depute one of their number to prepare detailed reports on the subjects, they would, I feel assured, produce a series of papers worthy of the Geologists' Association, which would materially add to the general stock of knowledge of the geology of the London District.

Visit to the Museum of Practical Geology.

The following description of the visit of the Association to Jermyn-street has been prepared by Mr. Marcus Scott, F.G.S. :—

On Saturday, the 18th of July, 1863, some of the members of the Association visited the Museum of Practical Geology, Jermyn-street, when Marcus W. T. Scott, F.G.S., Mine-Surveyor, &c., of 24, Great George-street, Westminster, gave a general explanation of the model of Her Majesty's Forest of Dean, which shows at a glance the greater part of the coal-field. The model was constructed by him (when with Mr. Sopwith, in Newcastle-on-Tyne, some 20 to 30 years ago), on a principle laid down by Mr. Sopwith, and fully described by drawings, &c., in his "Treatise on Isometrical Drawing," published in 1834. The model shows the principal of the surface-objects, roads, houses, inclosures, tramways, pits, &c., which were in existence at the time, all of which are painted in different colours. It is made of wood, and represents an area of

24 square miles, and is on a scale of 8 chains, or 176 yards, to an inch, the horizontal and vertical scale being the same (what is termed a natural scale). The surface is agreeably diversified by numerous undulations, varying in height from 120 to 1,000 feet above the level of the water in Lydney Basin, on the River Severn. The Forest is situated between the Rivers Severn and Wye, in the hundred of St. Briavels, and county of Gloucester. There are 3 series of coals, the highest series consists of 3 small inferior seams, called the "Woorgreens Coal." The middle series comprises 8 seams, varying from 1 foot 3 inches to 3 feet in thickness. Those principally worked are the Park End, High Delf or Lowrey, Rocky, Starkey, and Churchway High Delf. In the centre of the basin it is about 800 feet deep to the Park-End or Lowrey, and 940 feet to the Churchway, from the surface. The outcrop of these coals comprehend an area of about 7,000 acres. The third or lowest series comprise 5 seams of coal, varying from 1 to 4 feet thick, the principal coal being the Coleford High Delf, which will probably be 1,550 feet deep from the surface, in the centre of the basin; it is estimated to extend over an area of about 16,000 acres, and has been as yet only worked to a limited depth. The model in question was expressly made for the Museum, on a natural scale, by order of the late Sir H. De la Beche. The first model made on the principle was on a scale of 16 chains to an inch, horizontal, and a greatly enlarged vertical scale, and it was made to explain to the Commissioners of Woods and Forests the nature of the coal-basin. Immediately below the deepest coal there is a sandstone, in which there is a seam of iron-ore; below that sandstone there is a limestone in four beds, in which there are two layers of ironstone, disseminated in irregular pockets or caverns, called "Churns." The limestone rests on the old red sandstone, which is supposed to be 6,000 to 8,000 feet in thickness. The model is divided into 6 blocks, each 20 inches square; there are 4 square miles in each block. The mode in which the model was made was by drawing straight, north and south, and east and west, lines, each half-a-mile, or 5 inches apart, on the plan which was made for the purposes of the Dean Forest Mining Commissioners, appointed under Act of Parliament, 1 and 2 Vic., cap. 43. Levels were taken from the datum-line of

the water in Lydney Basin, over all the roads, tramways, and enclosure-drives. From these levels sections of the surface were constructed over the north and south and east and west lines, and lines representing the coal-seams to be exposed on the model were also drawn on the same sections—10 slips of plane-tree or sycamore wood, about $\frac{3}{16}$ths of an inch thick and 5 feet in length, corresponding with the north and south sections, and 15 slips of the same wood, each 3 feet 4 inches long, corresponding with the east and west sections, were prepared, of a uniform height, corresponding with the highest part of the model. On these slips of wood were drawn the surface-lines, and the lines of the coal-seams intended to be exposed by lifting up the same as were drawn on the sections. In drawing the coal-lines, an allowance was made for the thickness of the saw-cuts. These surface and underground lines gave points to carve the model out by, and the intermediate spaces were filled in from the sections of the several roads and tramways. These slips of wood were joined together crossways, by what is termed "half-lapping, the whole forming a series of 96 pigeon-holes. The surface- and coal-lines of each section were all sawn off and properly marked. Each pigeon-hole was fitted in with a block of lime-tree wood as deep as required, the greater part of the bottom of each block being hollow within.

Mr. Scott took the model to pieces, and exposed to view the outcrop of the several coals, the dip and the basin-like form in which they are deposited (the dip on the east side of the basin is much steeper than on the west side). The outcrop-line of the middle series of coals has very much the shape of the contour of the human left foot. The Coleford High Delf Seam is the lowest or deepest, shown on the model, to lift off. The next deepest is the Churchway High Delf, but it is only shown on the north-east block, where it had been most extensively worked. The highest coal shown is the Park-end High Delf or Lowrey seam. These were sufficient to explain the nature of the basin. The workings that had taken place, up to the time the model was made, are shown in the three seams, by different colours, the coal unworked being black. The scale being so small, no faults are shown, except what is called the "Horse,"—being a wide space where there is no coal, the roof and floor, in the Coleford High-Delf, meeting. There is a yellow level line drawn on each coal-seam, corresponding with the "independent free level," being the deepest free drainage-level in the Forest. There are also other level lines drawn on the several seams, at every hundred yards in depth below the "independent free level." The Coleford High Delf and some of the other coals and ironstones are worked by driving horse-levels into the sides of the hills, from the deep valleys.

In order to prevent the blocks of the model getting soiled by continual shifting, Mr. Scott contrived a double sliding table, by which means the several sections north and south and east and west, of the basin, are exhibited, without touching the blocks. There are sections of the strata shown all round each block, so that there are three north and south, and four east and west sections of the basin shown.

Mr. Scott briefly alluded to two models, on a large scale, of Shipley Colliery, by Woodhouse & Jeffcock. No. 1, showing the surface (which lifts up and is always suspended), in a similar way to the Dean Forest model, and shows the working on the "long wall system," with the several faces of coal and underground roads and arrangements. No. 2 shows the surface-arrangements and various other features connected with the mine. There are various other models of great interest in connection with mining well worthy of an inspection. Also the section of the Dolcoath Copper-lode, which was briefly alluded to.

Ordinary Meeting, December 1st, 1863.

Professor Tennant, F.G.S., President, in the Chair.

The following gentlemen were elected members of the Association:—Mr. John Thomas, Mr. Charles James Harris.

The following donations were announced:—

"*Abstract of Proceedings of the Geological Society.*" By the Society.

No. 1 of the "*Geologist.*" By J. H. Clement, Esq., F.G.S.

"*Report on Coal, Coke, and Coal-mining.*" By Rev. Thomas Wiltshire, M.A., F.G.S., &c.

The following papers were then read:—

1st. "On some New Localities for Fossil Fishes in the North of Scotland." By Mr. Geo. E. Roberts, F.A.S.L.

In a letter from the Rev. Mr. Joass, of Edderton, Ross-shire, to Sir R. I. Murchison, which was noticed in the "Quarterly Journal of the Geological Society" (vol. xviii, p. 553), mention was made of the discovery of a new exposure of sandstone strata, with two bands of clay full of calcareous nodules, containing plentiful remains of Coccosteus, Glyptolepis, and other type-fishes of the middle old red, in a burn about 2½ miles west of the manse of Edderton, and on the south side of the Dornoch Firth. Having paid a visit to this new and most interesting locality during the past summer, I propose to bring it and the fine fossils therefrom obtained before the notice of the Association this evening, in conjunction with some other fish-bearing localities, hitherto unrecorded. Thanks to the labours of the Rev. Mr. Joass, Mr. George Anderson of Inverness, Mr. Stables of Cawdor Castle, the Rev. Dr. Gordon of Birnie, and the Rev. Dr. Campbell of Tarbatness, the once restricted list of localities from which these remarkable nodules were obtained has been greatly extended during the past summer, and new specimens are being obtained from places where the existence of fossil fishes had been doubted.

Mr. Anderson writes to me under date Oct. 3rd:—

"It is interesting and curious how discoveries are sometimes multiplied in certain directions and at the same time. As you noticed at Edderton and Cawdor in July, the fossils of our old red are turning up in great numbers. It always seemed remarkable that close to Inverness, while we had long seen indications of them, only one layer with fish-scales existed. This was in a quarry south of the town, on the way to the great Druidical temple of the Leys. This 'platform of death,' as Hugh Miller would have called it, was so far isolated, that no other fish-bearing layer existed near it seemingly for miles. But just now, another layer has turned up in the same rock, and at the same place, containing great numbers of plates of *Coccosteus*."

An interesting discovery of fish-bearing strata has been lately made by Mr. Thomson, schoolmaster of the Free Church at Culcharry, near Cawdor (Nairn). The rock was met with in quarrying into a small escarpment of middle old red upon the farm of Knockdown, about two miles from Cawdor Castle. It appeared to me to be referable to the lowest Cromarty bed. Its lithological character was a stiff red clay, bearing nodules, which contained fish-remains, and, in a few instances fucoids. Coccosteus was the most frequent species. Other recently discovered localities for this and the associated species of Osteolepis, Diplacanthus, Glyptolepis, &c., &c., are Scotstown Burn and Ardross Castle, both in Ross-shire. The Rev. Mr. Clark of Middat (Ross) is pursuing an investigation into these, in conjunction with Mr. Joass. The celebrated locality of Tynet Burn, by Fochabers, from which so many fine specimens of Diplacanthus have been obtained, is in this zone of old red. A very large specimen of a new species of Pterichthys, sent to me from that place, is now the gem of the British Museum Pterichthyes.

The Edderton Burn is perhaps the richest deposit of Coccosteus known. Large nodules of the stone which contains this fish lie in the course of the stream, while thousands of smaller nodules, each containing an organic tenant, either Glyptolepis or Diplacanthus, are interspersed with fragments of other rocks throughout its extent. These nodules are, unfortunately, very tough and difficult to break open, generally splintering in the direction of the long axis of the stone, instead of splitting into two equal portions, so as to expose the contained fossil; so that to display a good specimen is of rare occurrence. The escutcheon-like plates of Coccosteus, so characteristic of that fish, occur at Edderton, tinted blue by phosphate of iron, thus rendering them easily distinguishable, and among the most beautiful of fossils. The specimen which Mr. Tennant permits me to exhibit shows this character in much perfection. This was the best specimen of Coccosteus obtained by me. The district of Tain is at present very difficult of approach, the railway passing no nearer than Invergordon, ten miles south of Tain, and about 17 from the Edderton Burn. A line to Tain is, however, in process of making.

The Edderton Burn district is a savage and singularly wild country, made up of broad moorland, hemmed about with lofty crags of fanciful shape, a fit surrounding to the graveyard in which lie the quaint and uncouth armour-clad fishes of the old red sandstone.

I may remark in conclusion that very few fossil fishes are now to be obtained at Cromarty. Lieutenant Pattison, who collected them after the departure of Hugh Miller, has left Scotland, and I met with no one who could give information as to the outcrop of the fish-bearing nodules.

2nd. "On the Geology of the neighbourhood of Rugby." By Mr. West.

Annual Meeting, January 5th, 1864.

The Annual Report was read as follows:—

REPORT.

During the past year the Association has steadily progressed in the direction of its proper position, that of an Amateur Society.

The meetings have been well attended by those members who reside in town, and by a larger proportion of country-members than have in past years been present.

Many papers have been read, some of considerable interest, and much information has been elicited by the discussions which have followed the reading of the papers.

The following papers have been read during the past year:—

"On the distribution of the Fossils of South America." By Mr. Carter Blake, F.G.S.

"On the Mines of the North of England." By Mr. Sopwith, M.A., F.R.S., F.G.S.

"On Paramoudras." By Mr. Charlesworth, F.G.S.

"On Fossil Sharks." By Mr. Charlesworth, F.G.S.

"On Fossil Monkeys." By Mr. Carter Blake, F.G.S.

"On the Geology of the Neighbourhood of Croydon." By Mr. Bott, F.G.S.

"On a Geological Ramble to the Neighbourhood of Maidstone." By Professor Tennant, F.G.S.

"On Microscopic Geology." By Mr. Hislop, F.R.A.S.

"On the Visit to Dudley." By Dr. C. T. Richardson.

"On some recent Marine Shells found in the Excavations for Railway-works at Preston." By Mr. Rofe, F.G.S.

"On the Geological distribution of the Pitharella Rickmani." By Mr. Evans.

"Observations on Ammonites, and on the Natural History of the Tribe of Molluscous Animals to which these remarkable extinct Shells are supposed to belong." By Mr. Charlesworth, F.G.S.

"On Fossil Elephants." By Mr. Carter Blake, F.G.S.

"On Fossils from the Railway-cuttings in the vicinity of London." By Mr. Evans.

"On some new localities for Fossil Fish in the North of Scotland." By Mr. Roberts.

"On the Geology of the Neighbourhood of Rugby." By Mr. West.

"On the Strata exposed by the Main Drainage Works at Peckham." By Mr. Bott, F.G.S.

The excursions to places of geological interest have proved as successful as in former years. On all these occasions the local geologists, and others feeling an interest in geology, have stepped forward to assist, and, on more than one occasion, have hospitably entertained the members of the Association who were present.

Visits have been made to the following places:—

Dudley, Dover, Herne Bay, Ipswich, Kensington Museum, Museum of Geology in Jermyn Street, Kew Gardens, College of Surgeons, British Museum, Zoological Gardens, &c.

The number of volumes in the Library has increased since the last Report, and it is satisfactory to state that, notwithstanding the large use which has been made of it, few, if any, of the books have been injured or lost.

The following is a copy of the Balance-sheet:—

Balance-sheet of Receipts and Disbursements.

	£	s.	d.		£	s.	d.
By Annual Subscriptions and Entrance-fees	99	17	0	Rent and House-expenses	33	1	4
By Life-subscriptions....	9	6	0	Printing, Engraving, &c.	33	19	6
By Interest on Stock	2	16	0	Editing and Reporting ..	6	6	0
By Balance from last Account	62	18	1½	Books, Binding, &c.	24	5	6
				Postage, Stationery, &c...	14	18	8
				Sundries	3	6	4
				Advertising............	2	2	0
				Commission............	2	18	6
				Balance	55	2	3½
	£176	0	1½		£176	0	1½

We have this day examined the accounts of the Treasurer of this Association and find a balance of £55 2s. 3½d. in his hands.

JNO. NOYES.

January 2nd, 1864. JNO. JONES.

In reporting the removal of the Association from No. 5, Cavendish Square, the Committee have much pleasure in announcing that they have made arrangements with the Council of the Medical Society of London to hold their Ordinary Monthly Meetings at the Rooms of that Society, No. 32, George Street, Hanover Square, an arrangement which they hope will meet with the approval of the Association, and be found to be permanently beneficial.

The Committee beg to recommend the following list of officers for the ensuing year:—

PRESIDENT.

E. Cresy.

VICE-PRESIDENTS.

J. Tennant, F.G.S.
J. Pickering.
T. Sopwith, M.A., F.G.S.
Rev. T. Wiltshire, M.A., F.G.S.

TREASURER.

Wm. Hislop, F.R.A.S., &c., 108, St. John Street Road, C.E.

GENERAL COMMITTEE.

T. Brain.
Edm. Jones, F.G.S.
C. Evans.
S. Highley, F.G.S.
W. N. Lawson, M.A.
J. Jones.
T. Lovick.
T. Dexter.
Dr. C. T. Richardson.
W. H. Leighton.
J. Rofe, F.G.S.
J. Noyes.

HONORARY SECRETARY.

J. Cumming, F.G.S., 7, Montague Place, Russell Square, W.C.

HONORARY LIBRARIAN.

A. Bott, A.A., F.G.S.

Ordinary Meeting, Tuesday, January 5th, 1864.

E. Cresy, President, in the Chair.

The following gentlemen were elected members of the Association:—Mr. John Gardner, Mr. Edmund Gardner, and Mr. Robert Irving.

The following donations were announced:—

"*Abstract of Proceedings of the Geological Society.*" By the Society.

A paper was read:—

"On the Fauna of the Carboniferous Epoch." By Professor Morris, F.G.S.

Ordinary Meeting, Tuesday, February 2nd, 1864.

E. Cresy, President, in the Chair.

The following gentleman was elected a member of the Association:—Mr. Edward Cooper.

The following donations were announced:—

"*Abstract of the Proceedings of the Geological Society.*" By the Society.

"*Versteigerung einer Mineralien-Sammlungs.*"

"*Quarterly Journal of the Geological Society.*" By the Society.

A paper was read,

"On Stones picked up in the Streets of London." By C. T. Richardson, M.D., Cantab.

Of all the classes of rocks there is not any class more easily recognised than that to which granite belongs. To the practised observer so distinctive and characteristic are the granite-rocks, that whether surveying them in the field as portions of the mountain-mass, or studying hand-specimens, we may say, in the words of one of our most intelligent naturalists, when describing the features of a granite mountain, Tres Montes, in South America, 2,400 feet high,—"Granite to the geologist is classic ground; from its wide-spread limits, and its beautiful and compact texture, few rocks have been more anciently recognised."—*Darwin's Naturalists' Voyage*, p. 284.

Of the critical specimens in the cabinet, scarcely a momentary doubt ever arises.

In the language of the text-books, and of most authors, granite is described as belonging to the Plutonic division, as distinguished from the Volcanic division of Igneous Rocks; or those presumed to have been formed under circumstances implying situations of great depths and other conditions of great pressure for their formation, as contrasted with those supposed to have been formed nearer to, at, or above the surface of our globe. Sir C. Lyell, taking a less general and more restricted view, apart from all other conditions, has named granite and its allies from the position in which it is usually found in relation to other rocks, designating them *Hypogenous* or *Nether-formed* rocks, as lying at the base of all.

The appearance which granite presents is familiar to most all of you, and is that of a granular crystalline mass, an assemblage or aggregation of crystalline substances of varying degrees of size, all more or less uniformly and thoroughly incorporated together, presenting a highly sparkling appearance upon recent fracture. To these may be added a greater or less degree of hardness—density and closeness, or compactness of structure, with an almost entire absence of the features of stratification, foliation, lamination, or cleavage, which so peculiarly prevail throughout the sedimentary and altered rocks, and distinguish them as a class from the crystalline igneous rocks.

Thus summarily reviewed and described, granite, as a rock, is of easy recognition; but when more closely examined and scrutinized, its structure reveals to us features of far more definite character, value, and importance, varying in interest only with the purposes, views, and objects, of the investigator, and the course and method of his examination. For instance, the *Geologist* will content himself with the recognition of the presence and co-existence of certain substances of crystalline form well known to him, mixed up and incorporated together, more or less intimately, without any definite or perceptible order, and coupling therewith the characters just enumerated, sees and describes it only as a crystalline amorphous rock, containing certain elements, and of a presumed special source and origin, found usually in certain uniform relations to other rocks.

The Mineralogist will separate the elements composing the mass from each other, and by the mode of his investigation discovers the elements of the mass to consist of substances well known to him, presenting certain definite, constant, and unvarying forms called crystals, which pervade and are met with throughout the whole series and varieties of allied rocks; and he is thus enabled, according to the character, proportions, and variety in which they are present together, to base thereupon a classification, and calls the mass either a binary, ternary, or quarternary compound rock, modified by the presence of any distinctive element.

The Chemist also investigates, but still more closely, and examines into the intimate composition of these several supposed elements, and in revealing to us their nature and history, tells us that this apparently simple crystalline amorphous mass (granite) is a composition, possessing very highly interesting and complex chemical interest, containing combinations of definite and intricate proportional accuracy, of minutely divided degrees of atomic combining power; and that not only were these combinations brought about and affected by laws not dissimilar to those which still affect and regulate the present great operations of nature, but that they must, from their very nature, only have been realized under their long continued intensity, and almost incomprehensible degree of active force; and so are we thus led on from the simple mechanical consideration and thought, to the far wider field of philosophical investigation, and mental contemplation of the interesting question of the source and origin of granite, and the supposed conditions under which it has been formed.

But before entering upon this it will be as well to consider some of the simpler and necessary features of its composition and history, and of the substances entering therein.

Granite in the ordinary form so well known to us is a compound of the three crystalline substances, *Quartz*, *Felspar*, *and Mica*, of general uniform size, and in certain proportions, and so thoroughly incorporated and dispersed in the mass as to present a tolerable regularity and compactness of structure, varying only with the size of the several crystals in its degrees of fineness, &c. Under this form it is usually spoken of as true, typical, or standard granite, and from the necessary co-existence of the three elements of its composition, it is called also ternary granite. From this type there are many variations, not only in the co-existence of these three elements and the degrees and proportions in which they are present, but also from the absence of some of them, and their substitution by some one or other of a class of substances other than those already spoken of, which are found to be present in some granite, and thus, according to the number of elements present we get binary, ternary, or quaternary compounds as granites.

Composition of ordinary granite is—

Silica	72·3
Alumina	15·3
Alkalis	7·4
Lime, magnesia, iron	5·0

Consisting thus generally of about		40	per cent. of	felspar.
„	„	30 or 40	„	quartz.
„	„	10 to + 20	„	mica.

The substances thus entering into the composition of all granites whether *binary*, *ternary*, or *quaternary*, and those which by their presence constitute the variations from the true character of granite, and give especial designation to the varied compounds, may be divided into two classes:—

The Essential—consisting of quartz, felspar, mica, hornblende.

The Accidental—hornblende, hypersthene, actinolite, steatite, talc, and schorl or tourmaline.

QUARTZ is present in all true granite, and in most granitic rocks, and is generally a very prominent and visible element of their composition, presenting more or less perfectly the clear transparency of crystalline character, varying in colour from that of a silvery gray to white and other colours, according to circumstances, and in the size of its crystals from distinct isolated nodules of the coarser textures to that of the smaller granules of the closer and more compact. Its chemical composition is that of pure silica (SiO^2), belonging to the 3rd system of crystalline forms, or that of the hexagonal or six-sided prism, terminated by corresponding pyramidal surfaces, and having a specific gravity of 2·65, and a very great degree of hardness.

Of FELSPAR we have three recognised forms or varieties in granite, differing from each other in the nature of the alkaline base of their composition, and the proportions in which the base enters into combination with the other substances. Thus we have—

Orthoclase	or Potash-felspar,	with	Potash as a base.
Albite	„ Soda-felspar,	„	Soda as a base.
Oligoclase	„ Soda-felspar,	„	Soda as a base.

But this latter in greater proportional combinations.

ORTHOCLASE is composed of 1 equivalent of trisilicate of potash, and 1 monosilicate of alumina; as a crystalline form it assumes that of the 5th system or the oblique prism, it is slightly flesh-coloured, less hard than quartz, and has a sp. gravity of 2·5 or 6.

ALBITE, or Soda-felspar, has one equivalent of monosilicate of soda, and 1 equivalent of monosilicate of alumina; crystallises in the form of the 6th system, or that of the doubly oblique prism; is of a more or less dull white aspect, and has a specific gravity of 2·6.

OLIGOCLASE is supposed to be composed of 3 equivalents of monosilicate of soda, and 4 equivalents of monosilicate of alumina; crystallises also according to the form of the 6th system, or doubly oblique prism, and has a specific gravity of 2·6, with a degree of hardness similar to that of orthoclase.

There are, however, many varieties of Felspars, but they have a general composition of silica about 65; alumina, 18; potash or soda, 12 to 16. (See Catalogue of, or Guide to the Jermyn-street Museum, p. 78.)

Felspars enter of necessity into the composition of all granite, and form also a very prominent element, more or less, of nearly all igneous rocks, and give by their presence, according to the respective variety, much of the distinctive characters which granites assume, and also some of those features which are of the most importance in the practical sphere to which my observations more especially relate this evening, namely, in paving-stones. Felspars occur in all varieties of size, as crystals, and in some forms of granite, as the porphyritic, of distinct size and separate.

Felspar seldom forms less than half the mass, and never less than one third, whilst both mica and quartz are in smaller proportions, sometimes in so very reduced quantities as to be scarcely visible.

Mica, the third of the essential elements to be considered, is always present in what is called true granites, and is usually seen as smaller or larger lamellæ, or scales of bright sparkling or glistening character, and of almost every variety of colour, from that of the lightest shade of white to that of the deepest black. There is also similar variety of composition, some containing potash, lithia, lime, magnesia, iron, &c., in varied quantities, and presenting corresponding varieties of appearance. There are, however, three more distinctly recognised and more usually met with than others, viz.:—

Margarodite, *Lepidomelane*, and *Muscovite* or Potash-mica, the most frequent of all, being the ordinary form usually seen.

Muscovite or Potash-mica is crystalline, biaxal, of the 5th or oblique prismatic system, is composed of 1 equivalent of trisilicate of potash to 3 equivalents of tribasic silicate of alumina, part of the potash being replaced by lime and protoxides of iron and manganese, and part of the alumina by sesqui-oxide of iron, manganese, &c.

Margarodite or pearl-white Mica is also biaxal, has specific gravity 3·0 1, and is of a pale greenish white, with a pearly lustre.

Lepidomelane or black Mica is uniaxal, of dark colour, and of metallic lustre.

These two differ considerably in their composition, not so much as to the actual substances entering into as in the proportions in which they are present. Their minute analysis is not necessary for our purpose, the presence of mica and its varieties being all that is required.

The Accidental Substances.

Talc.—5 equivs. of silica to 4 of magnesia. Of 3rd S., occurs in rhombic and 6-sided tabular crystals. Sp. gr. 2·7.

Steatite.—4 equivs. of silica to 3 of sp. gr. magnesia 2 ·6.

Hornblende or *Amphibole.*—6 equivs. of silica to 5 of mag. and lime, with protoxide of iron and manganese, is of 5th S. or oblique prismatic. Sp. gr. 3·2. Colour dark-green, sometimes almost black.

Actinolite.—Similar composition to Hornblende; is coloured green by chromium and iron. Sp. gr. 3·03.

Pyroxene or *Augite.*—Monosilicate of magnesia and lime, or 2 equivs. of silica to 1 of magnesia and 1 of lime, is of 5th S. or oblique prismatic.

Schorl or *Tourmaline.*—A combination of a double silicate with a *borate.* An obtuse rhombohedron of the 3rd system. Sp. gr. 3·3. Softer than quartz. Variously coloured. Has every degree of transparency from clearness to opacity.

Analysis of Schorl.—10 per cent. boracic acid.
39 „ silica.
31 „ alumina.
4 to 12 protoxide of iron.
2 to 9 magnesia.
Lithia, potash, soda.

Associated also with granite as a paving-stone in our streets, are otner rock-substances of closely allied characters and history as to origin, composition, and surrounding circumstances; and, although they do not realize and attain to what is considered and recognised as the true formula of the composition of granite as true and typical, are yet commonly spoken of as such, and used for some of its ordinary purposes. . They possess many of the general external characters, have a similar amorphous and irregular arrangement of their semi-crystalline and granular structure—are hard, dense, compact, and differ from true granites rather as chemical compounds, in the absence, either proportional or entire, of some of the essential elements, and the substitution and introduction of some of the class of accidental elements, than in their physical and external characters, and are consequently spoken of and described as Granitiform and Granitoid Rocks, from their greater or less similitude or approach to the aspect of True Granites. Of these the most prominent illustrations are Syenite, and its variations and allies, Greenstones, Porphyries, and such like, all frequently found either in the well-known size of modern street-pavement, or in the more comminuted form applied to the macadamized road. In some of the older street-pavements in bye-neighbourhoods, where the modern and costly system of dressed stones has not been introduced, the old-fashioned water-worn stone or cobble, little altered in shape, may yet be met with in roadways or crossing-pavements, and after rain these may be seen to consist of a great variety of stones of this class, as well as of granites of all colours, textures, and densities. I have also found other hard compact trappean rocks, basalt, and gneiss, but all more rarely.

Syenite possesses many of the external characters of granite, and approaches so closely to it in some forms that we are accustomed to hear syenitic granite spoken of and described, and we see it to have been applied in the days of the older kingdoms of the world to numerous similar purposes to that of granite, as the contents of our several collections of antiquities bear evidence.

It is a very hard stone, and as such was sought for for the purposes of paving even before the general adoption of granite, being generally far more durable than many of the varieties of that rock.

Its composition is not very dissimilar to granite, containing one element in excess of that of true granite.

Quartz, Felspar, and Mica constitute true granite, but when Hornblende (a substance composed of 6 equivs. of silica and 5 equivs. of magnesia and lime, with protoxide of iron and manganese) enters into the composition, we have a Quaternary, or Syenitic, or Hornblendic granite. And when the Mica disappears, and we have a compound of three, Quartz, Felspar, and Hornblende, it is considered a Syenite. It therefore differs only in the substitution of one chemical element of its composition for another, Hornblende instead of Mica, and preserves more or less the appearance of a crystalline aggregated mass, as does granite.

Greenstone, in like manner, by the forfeiture of quartz, consisting of Felspar and Hornblende, presents sometimes a coarsely grained or compact crystalline character, hard and dense, rendering it a serviceable substitute for granite as a paving-stone. It is an igneous rock, but differs from granite in many points as to the mode of its occurrence and other features.

This brief and cursory outline of the chemical composition of granite, and of some of the other rocks allied to it in constitutional characters, and associated with it in our economic and practical uses, will be sufficient upon the present occasion to show to you the beauty, interest, and complexity which they present when minutely scrutinised and investigated,—how apparently slight, though definite, are the degrees and shades of variation of the several elements which compose them; and also enable me to call your attention more immediately to the circumstances which render these several rock-masses so especially qualified by their lasting and enduring properties to fulfil the purposes to which we adapt them in our streets.

According to the Descriptive Guide of the Jermyn-street Museum, there are exported—

From Bovey Heathfield, Devon, 20,000 tons annually.

In 1855, 60,188 tons of china-clay or kaolin were obtained and exported from Cornwall, and 1,100 from Devonshire.

In that year alone the quantities exported from the Cornish and Devon districts, *as potters' material*, represented a money-value of £80,059 4s.

The facilities with which granites decompose and decay, as will be readily understood, depend partly upon the characters of their structure as to compactness and closeness, and their varied degrees, and also to the nature of mineral matters entering into their compositions. The denser and closer textures will longer resist the admission of water than the coarser, and thus one great decomposing agent is rejected for a longer or shorter time. Much diversity of opinion, however, exists, even among men well qualified to judge upon the matter, as to which is the element most easily yielding, and promoting the process of decay; and nearly each element of the mass has in turn had its advocates—one cites some especial form of felspar, another points to some peculiar form of mica, another to the yielding of the matrix cementing the materials in one, another to the interstitial absorption of water and and its disintegrating action under the several variations of thermal influence, and another to the chemical action of water when so admitted in promoting the oxidation, with more or less ease, of some particular mineral element existing in the mass. That each and all may in turns be right is beyond all doubt, for we see and recognise in any of the older mountain-watercourses the whitened margin betokening the felspathic decay of the fractured water-worn pebble of some igneous rock, and the well-known brown and weathered aspect of hornblendic rock under similar circumstances; we see quartz set free from both, and mica exfoliate; and many a granite-surface which comes perchance bright, clear, and glistening fresh from the chisel to-day, ere very long has become dulled and lustreless by the exposure to the action of our ordinary atmosphere. The mechanical absorption of water, the interstitial, as distinguished from the hygroscopic or chemical water existing in most crystals, with granites is doubtless a very potent agent co-operating with atmospheric and thermal variations in inducing disintegration and decay—the coarser-grained structures admitting it most easily, and disintegrating with great readiness in comparison with the closer and more compact; hence the existence of the large amount of special interest attached to the Cornish and Devonian granite-regions already mentioned, as compared with other localities. A paper read before the Society during one of our previous sessions, upon the relative qualities of our ordinary building-stones, told us that even the densest of all granites was capable of absorbing water to the amount of 1 per cent. And it is related by the well-known authority of Wilkinson's *Practical Geology and Ancient Architecture of Ireland*, and by Sir

R. Kane in his *Industrial Resources of Ireland*, that Irish granites, varying in weight from 143lbs. to 176lbs. per cubic foot, absorbed, after 88 hours' immersion in water, quantities varying from $\frac{1}{4}$ of a pound to 2lbs. and 4lbs. It has been said, and would also seem to bear the evidence of truth, if one may judge from the quantity of coarse-grained granites used for building-materials as foundations upon proper bases, constantly under water, that they not only do not then decay, but are capable of great endurance, a circumstance corroborating the action which is ascribed to atmospheric exposure.

Granite is generally considered as not a strictly eruptive rock, not poured out like modern lava, overlying and enveloping all beneath it, but coming from beneath in greater or less masses, elevating districts with an apparently long and gradually acting force over wide areas, as our Devonian and Cornish instances may well illustrate.

The Channel Islands also present a very large and interesting variety of crystalline igneous rocks, mostly in the form of syenites, porphyries, and gneissose rocks; granite, as true granite, forming a very small portion of their masses.

I hope, however, enough has been said to enlist you into the consideration of the paving-stones of our streets, and to invest them with interest in your thoughts.

Ordinary Meeting, Tuesday, March 1st, 1864.

Mr. E. Cresy, President, in the Chair.

The following gentleman was elected a member of the Association:—Mr. James Romanes.

The following donations were announced:—

"*Abstract of Proceedings of the Geological Society.*" By the Society.

"*Quarterly Journal of the Geological Society.*" By the Society.

"*Proceedings of the Liverpool Literary and Philosophical Society.*" By the Society.

"*Anthropological Review, No.* 17, *Vol. I.*" By the Anthropological Society.

"*The Negro's Place in Nature.*" By the Anthropological Society.

"*Spargo's Statistics and Observations on the Mines of Cornwall and Devon.*" By the Author, 1864.

"*The* 49*th Annual Report of the Royal Institution of Cornwall,* 1863." By the Institution.

"*Report of the Birmingham and Midland Institute,* 1864."

"*Proceedings of the Berwickshire Naturalists' Club,* 1863."

A paper was read,

"On the Laurentian Formation, its Mineral Constituents, Geographical Distribution, and its Residuary Elements of Life." By Dr. J. J. Bigsby, F.G.S.

CATALOGUE OF BOOKS IN THE LIBRARY.

Advanced Text-book of Geology .... D. Page, F.G.S.
Anthropological Review, vol. i, 1863
British Fossils, Catalogue of................................... Prof. Morris.
British Land and Freshwater Shells .... L. Reeve.
Bridgewater Treatise, 2 vols.................................. Dr. Buckland.
Cruise of the "Betsey" .... Hugh Miller.
English Cyclopædia of Natural History, vols. i, ii, iii, iv.
Fossils of the British Museum .... Dr. Mantell.
First Impressions of England and its People .... Hugh Miller.
Foot-prints of the Creator .... Hugh Miller.
Geology of Weymouth and the Isle of Portland .... R. Damon.
Geological Excursions, Isle of Wight, &c. .... Dr. Mantell.
Geologist, The vols. i, ii, iii, iv.
Geology: Is it antagonistic to Scripture?
Geology in the Garden.. Hy. Eley, M.A.
Geology of Sussex .... F. Dixon, F.G.S.
Geology of the Mountain-limestone District .... Prof. Phillips.
Geology of the Yorkshire Coast .... Prof. Phillips.
Geology of Leek.. T. Wardle, F.G.S.
Glossary of Mineralogy................................. H. W. Bristow, F.G.S.
Geological Map of the British Isles.
Gryphœa Incurva.
Handbook of Geological Terms.......................... David Page, F.G.S.
Historic Society of Lancashire and Cheshire Transactions, vols. i, ii.
Indian Catalogue. Exhibition, 1862.
Journal of the Royal Geographical Society of London, vols. xxiv, xxv, xxvi, xxvii.
Kingdom of Italy, Catalogue. Exhibition, 1862.
Life: Its Origin and Succession .... Prof. Phillips.
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PROCEEDINGS

OF THE

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No. 11.] [Session 1864-5.

"Notes on Microscopic Geology, No. 1."* By Mr. W. Hislop, F.R.A.S.

BEFORE entering on the immediate subject indicated by the title of this paper, I had better explain my object in putting before you these detached notes. I originally intended to draw up a continuous paper on the subject; but I find that so little has been done in the way of digesting the material scattered up and down in various transactions, papers, and other sources of information, that it would occupy more time and require more ability than I have at command, to render such a complete paper worthy of the subject and of our Association. I have, therefore, decided on delaying no longer, but will endeavour to bring the matter before you in a few detached notes, which I hope may prove complete in themselves, and at the same time trust that they will put the Society in possession of the latest discoveries in microscopic geology.

To those who have only directed their attention to the general features of our science, and have examined minerals, rocks, and fossils in the more popular manner, it may seem difficult to apply the microscope to the study of these objects. While they can appreciate the cursory application of the hand-lens to the specimens under observation, the majority of geologists, whether students

* Read before the Association, June 1st, 1863. The publication of this Note has been delayed until the present time, in order that it might be placed in juxtaposition with Notes Nos. 2 and 3. See pages 378 and 386.

or professors, do not employ the achromatic microscope to anything like the extent which is desirable and warranted by its value in other branches of natural history. The character of a deposit may be often satisfactorily determined, and its position defined, by an examination of the minute forms contained therein; while very great light may be thrown upon the manner of its formation, and the probable changes which have taken place in its physical condition.

Take an instance in the organisms named Xanthidia by Ehrenberg, and placed by him in a distinct genus among what he called "Infusoria." These bodies are often found in flint, and in very large quantities. They are preserved with marvellous perfection, and exhibit all the details of their structure with very great beauty when properly examined. The microscope has brought us acquainted with a class of recent forms known as Desmidieæ, which appear to occupy a portion of the debateable ground between the animal and vegetable kingdoms. Many of them in the recent state possess the power of independent motion, and exhibit the curious ciliary arrangement over portions of their external and internal surfaces, which is so often found in animal structures. These organisms are generally regarded as minute plants. They are found in clear pellucid water, generally on open heaths, moors, or bogs, sometimes attached to the large plants growing in the water, or lying upon the stones, or on the surface of the mud at the bottom of the pool. They are usually enveloped in a clear mass of gelatinous matter, and present within this covering some most beautiful and exquisite forms. They are continued and increased by spores, which sometimes separate from the parent plant in a similar form, but very frequently take quite a different shape. The sporangia of some species resemble almost exactly the Xanthidia of Ehrenberg. They are exceedingly delicate in their structure, the slightest pressure or disturbance being sufficient to mutilate or destroy them. From this cause it is a difficult matter to preserve both the perfect forms and the sporangia for future examination, it being necessary to immerse them in some fluid, which shall preserve their structure intact and uninjured, for if dried, all traces of their original beauty and form are lost.

This in the case of the flints before us has been done during a period of time extending over ages; these minute forms being embedded in one of the hardest substances known in nature, suggest to us the inevitable conclusion, that at some period of time the flint must have been in a perfectly fluid state, or else the delicate forms could never have entered and been preserved within its substance. It also points out that the process of congelation of this fluid medium must have been without contraction or bringing of the particles closer together, as may be supposed to happen in the process of crystallization or congelation, otherwise the organism would present some alteration of form, or, more probably, would be entirely destroyed by a change which involves an enormous force of pressure.

Again, a large proportion of the rock which prevails through an extensive district in the Island of Barbadoes, has been found by Ehrenberg to be composed of Polycystina, a name given provisionally to a series of forms, the origin and position of which is but little understood. As an illustration of the enormous number of these geological remains, I may state that Ehrenberg found 39 species of the Polycystina in the Barbadoes earth, but Sir R. H. Schomburgk has estimated the number observed by him in that deposit to be 282. Many of these forms are identical with those brought up from the bottom of the Atlantic by means of the apparatus designed for the purpose of obtaining deep-sea soundings, and noticing the nature of the bottom. These last are no doubt of recent origin; but the fact points out the manner in which the Barbadoes deposit has been most probably formed. But the especial point to which I would allude is the occurrence of certain remarkable easel-like forms among these organisms, and the peculiar pitted structure which they exhibit. This particular structure has been found to characterize the calcareous shells and framework of the Echinidæ, and to obtain through all the changes which that curious class of animals exhibits. The skeleton of the Echinidæ has been found at one time of its existence to be internal, and in this, its larval condition, several species have been described by Müller, Gosse, and others. These marvellous easel-like forms greatly resemble some of the Barbadoes Polycystina, both in their external form and in their pitted structure. This evidently suggests that the latter may be the skeletons of the larval forms of larger marine animals, concerning which forms our knowledge even of recent species is at present extremely limited.

Careful generalization is in this, as in every other case, absolutely necessary. It is not enough to find a minute form in great profusion in a deposit to determine at once that that deposit was formed by the agency of the bodies found there. It has been supposed by some that, because Foraminifera are found in large quantities in the Chalk, therefore those enormous masses, sections of which are so well exhibited on our coasts, owe their production to these minute animals. Probably a close examination of specimens from different localities will show that Foraminifera are not nearly so numerous as might have been supposed, and that, taken as a whole, there is a much larger proportion of calcareous matter in the shells of the animals, the fragments of which are found in such enormous profusion throughout these deposits, and which probably present a more likely and abundant source for the production of these cretaceous deposits.

In this introductory note I do not propose to stay to speak of individual species; but it is desirable briefly to indicate the kind of instrument to be used, and the method of manipulation. Nothing very elaborate is required. A firm and simple stand, with good inch and quarter-inch achromatic object-glasses, is all that is necessary; but the objective must be well corrected, or fallacious appearances may present themselves. Some of the forms of students' microscopes are probably the best for the purpose, and a very useful instrument of this kind may be obtained from many makers at an outlay of five pounds. It is necessary to be provided with nitric and muriatic acids, and a strong solution of potash in the form of "liquor potassæ." Many deposits exhibit the forms within them by simply taking some of the powder scraped with a penknife, or abraded by handling, and placing it on a slip of glass beneath the object-glass; but most require cleansing from extraneous matter.

If the presence of siliceous forms is suspected, some of the powder should be boiled in a test-tube with diluted nitric or muriatic acid. This will dissolve away the calcareous matter, and, after washing and drying, the deposit may be examined with a low power, and any form that may appear may be removed with the point of a camel's hair pencil to a separate slip of glass, for future examination. The same course should be followed to obtain calcareous forms, substituting liquor potassæ for acids. If the deposit obtained after the washing and boiling be sufficiently rich, it may at once be mounted for preservation, either as opaque or transparent objects. The latter are generally the most useful. For this purpose the objects are generally immersed in Canada balsam, thinned with turpentine, and applied by dropping it on the objects previously arranged on a slip of glass. If properly dried, and the slip of glass carefully warmed over a lamp, the balsam will permeate the structure, and render it transparent without obliterating details. A thin disc of glass, previously warmed, should be laid on the surface of the balsam, and pressed to exclude any superfluity, and the object may then be cooled, labelled, and stowed away in box or cabinet, for future use. Opaque objects should be mounted in a small orifice bored in a thin piece of wood, and backed with black paper. They should be preserved from injury by a thin disc of glass, and the light can then be thrown upon them in any required direction.

In future notes I shall probably indicate the treatment to be preserved in especial cases which may arise in our consideration of the various forms known to microscopic geology.

The microscope so extends our power of observation as virtually to introduce us to a new world. New forms and facts meet us at every turn, and to the student of any branch of natural history it must ever prove an invaluable aid both as an instrument of analysis and as a portal to new discoveries.

Ordinary Meeting, April 5, 1864.

E. Cresy, Esq., President, in the Chair.

The following papers were read—

No. 1. "On the Possible Physical Causes and Molecular and

Crystalline action concerned in the Elevation of Mountain-Masses, and in Earthquakes." By S. J. Mackie, F.G.S.

The discussion upon the paper was adjourned until the next meeting.

No. 2. "Microscopic Geology. Note No. 2: Diatomaceæ." By Mr. Wm. Hislop, F.R.A.S., illustrated, with the assistance of Mr. Samuel Highley, F.G.S., by the oxy-hydrogen light.

There exists, very low down in the artificial scale of life, an ill-defined region, between the animal and vegetable kingdoms. Among aquatic organisms especially, there are found some extraordinary forms, of which it is difficult to discover the precise character, so as to determine whether they are plants or animals, and some of which, indeed, exhibit the attributes of animals at one time of their existence, and of plants at another. In this, as in numerous other instances, the practical naturalist finds a difficulty in tracing the line of demarcation so definitely drawn in the systems of books; and he will often experience this difficulty, not merely in naming a species, but in determining what genera, what group, or even to which of the two great divisions, called the Animal and Vegetable Kingdoms, his species belongs. Occupying this debateable ground, this nebulous space, and uniting in themselves certain properties, which have been generally supposed to belong exclusively to each, we find the curious organisms of which we have to speak to-night, and which are known as Diatomaceæ. Extremely minute as they are, requiring, even for their discovery, a high magnifying power, and for the definition of their intricate forms and details, still higher amplification, they yet present some of the most beautiful combinations of outline, marking, and structure to be found in nature; and by their enormous quantity, and rapid increase, they have exercised no inconsiderable influence in the formation of various strata composing the crust of the earth. Although genera and species have been studied to a large extent, but little has yet been done in applying this knowledge to the determination of the date and superposition of rocks in which fossil specimens are found, although it is evident that close observation must add some important information on this part of practical geology. This is due, in some measure, to the want of microscopic observers among geologists; and one care of a Society like ours is to bring together those who may separately follow some track of investigation, the results of which, when added to the common stock, may lead to important generalizations. If Members would send to the Association specimens requiring microscopic examination, we have at our command the means of verifying and recording facts which would eventually add greatly to the value of individual observation.

In my first note, I alluded to the existence of some beautiful forms in flint, which, when first discovered by Ehrenberg, were supposed to compose a separate family of Infusoria, or minute aquatic animals, and were named Xanthidia. Subsequent microscopic investigations have revealed a class of organisms which have been called Desmidieæ, and which possess certain characteristics belonging to the vegetable kingdom, but which seem to come near the debateable ground I have alluded to, although more closely allied to plants than Diatomaceæ. These Desmids multiply themselves by spores or seeds, which are precisely similar to the Xanthidia in flint. In the recent state, they are so soft and delicate that a touch will destroy them. They are, therefore, surrounded by a kind of mucilage, enveloped in which, they are attached to the stems of water-plants, or repose at the bottom of the clear pellucid pools of our heaths and moors. Their excessive delicacy, and the character of their surrounding envelope, are strongly suggestive of the fluid, or at any rate semi-fluid, origin of one of the hardest substances known in geology. Occupying a somewhat more dubious position, but possessing many features in common with the Desmidieæ, we find the Diatomaceæ. They are aquatic, or at least are only likely to exist where moisture abounds. Many of them are similar in colour to some of the Desmids, namely, of a pale or brownish green. They multiply by self-division or by spores, like them, but they are found in much larger quantities, so great as even, in their recent state, to tint the waters and banks amidst which they are found. They possess, in addition, a siliceous frame-work or shell, which being almost indestructible, is found, in various species, most abundantly in various strata of the earth's surface.

Most of the forms which have been found in a fossil state are also known to exist at the present time; and it is highly probable that more extended investigation will leave comparatively few species to be placed among extinct forms. I shall therefore seek to describe the characteristics of a recent Diatom, as this course will tend to throw more light upon the probable conditions under which those comparatively vast deposits have been formed, with which geological research has made us familiar.

The class of Diatomaceæ is a very large one, and possesses a great number of genera and species. They are inhabitants of the sea, and of brackish and fresh water, in this respect being different to Desmidieæ, which are found in the purest fresh water only. They are found reposing at the bottom of still pools, or attached to the fronds of sea-weeds, and covering the mud at low water, in layers of greater or less thickness, sometimes in gelatinous masses, at other times in delicate thread-like aggregations; but in all cases the mass is made up of a vast number of repetitions of some particular form, characteristic of the species, and connected together with more or less stability, sometimes by a stalk, rachis, or thread, and at other times merely by the gelatinous substance around them. These primary forms are perfect in themselves, and exhibit the utmost symmetry and beauty, both in outline and detail.*

They may be described as one-celled organisms, composed of two opposite plates or valves, generally convex, and of an interposed connecting third segment, altogether forming a siliceous box, enclosing a soft organic matter, sometimes green, but generally yellowish or brown in colour. Each individual form is called a frustule or a frond, and may be regarded simply as a cell. Their shape is very various, exhibiting square, circular, oval, triangular, and compound forms. They vary greatly in size; some individual frustules can be seen by the naked eye, while others require the highest powers of the microscope to display them. Whether found aggregated together in gelatinous masses, or attached by a stalk, the frustules are always alike in possessing the remarkable siliceous framework I

* Ralf says, that the sides of ditches in brackish marshes are very prolific, especially after spring tides. Capital gatherings are obtainable by scraping the brownish-coloured layer from mooring-posts, or the piles of wharfs and jetties.

have alluded to. This is unaffected by a red heat, or by strong acids, which would corrode and dissolve every other substance belonging to an organic being. The relative proportion of silex varies greatly in different species, and when macerated in acid, the cell-membrane disappears, and the empty space appears as perforations.

The surface of diatomaceous frustules is generally very beautifully sculptured, and the markings assume the appearance of dots, stripes, ridges, furrows, fine lines, and cells, variously disposed and arranged. Modern microscopic research has shown that these spots, lines, and various other markings are not always of the same nature. In some cases a dot may be a depression, and in another an elevation, while in a third it may be a thickening of the siliceous film. Lines also may vary in the same manner, or may be foldings or indentations of the same film. The fine lines, which a magnifier of a certain power may render visible, may be resolvable by a higher power into rows of minute dots, as is the case in species of Navicula, Pleurosigma, or Gyrosigma. In this instance we have a curious parallel in the use of the telescope. Those masses of luminous mist, known as nebulæ, are mostly resolvable by high magnifying power into clouds of stars so minute and dust-like, by reason of their inconceivable distance, as to produce the effect of luminous clouds. The extreme numbers of the markings on the frustules of Diatomaceæ has led to their being employed as tests of the efficiency and magnifying powers of our instruments.*

Minute as these organisms are, they are capable of producing great results, by reason of their wonderful facility of multiplication. One of the methods is by self-division; and so soon as a frustule is divided into two, each of the new individuals at once proceeds with the act of self-division, so that, to use Prof. Smith's approximative calculation of the possible rapidity of multiplication, supposing the process to occupy in a single instance twenty-four hours, "we should have as the progeny of a single frustule the amazing num-

* These markings are very beautifully shown in the photograph forming the frontispiece, the negative of which was executed by Dr. Maddox; and has been kindly lent to the Association by Mr. How, of Foster Lane, the publisher of Dr. Maddox's exquisite series of photographs of microscopic objects.

ber of one thousand millions in a single month; a circumstance which will in some degree explain the sudden, or at least rapid, appearance of vast numbers of these organisms in localities where they were but a short time previously either unrecognized, or only sparingly diffused."

The distribution of species is very wide and uniform. Numerous forms are common to many localities in Europe, Smyrna, Ceylon, the Sandwich Islands, New Zealand, New York, the loftiest accessible points of the Himalayas, and of the Andes. One species is found in the geysers of Iceland and in the lakes of Switzerland. Some have supposed that many species of Diatomaceæ occupy a very limited geographical area, and that considerable numbers have in the course of ages disappeared or become extinct, as many animal or vegetable organisms have done. Dr. Gregory, in a communication read before the Royal Society of Edinburgh, makes the following remarks in relation to a form previously considered as only fossil: "I have selected this form because the bed in which it occurs fossil is the oldest in which Ehrenberg has found any Diatoms. He has indeed found microscopic organisms in the Chalk, and even in old rocks, among which he mentions the Mountain-limestone, and the Silurian green sand; but the forms in the two latter rocks are not numerous, and as well as those which abound in the Chalk, belong to the Foraminifera or to the Polycystina, not to the Diatomaceæ. In short, I have no hesitation in saying that I believe all the forms in the Ægina clay-marl, which is the oldest Diatomaceous deposit yet described, will be found living on our coasts." He goes on to say: "Of all the forms figured by Ehrenberg from more recent strata, whether Miocene, like the bed on which the city of Richmond, in Virginia, is built, and several kinds of Bergmehl,—or Pliocene, like other Bergmehls, or polishing slates,—the great majority are perfectly identical with existing Diatoms. Indeed, although many forms are stated in Ehrenberg's earliest writings to be fossil only, and have been supposed to be extinct, the progress of observation is continually adding to the number of species which are found in the recent state. Taking these facts into consideration, I am led to believe that we have no evidence that any species of Diatom has become extinct, as so many species, genera, and tribes of more highly organised beings have done." He therefore concludes that "the whole of the species which occur fossil will ere long be detected in the recent state." There is at present no good evidence of the existence of Diatoms earlier than the Chalk, if so early. But we must not forget that the shells of Diatoms appear to be altered by long contact with carbonate of lime, so they may have existed at one time in the Chalk. We find them, however, in spite of the action of calcareous matter in the chalk-marls of Meudon or Caltanisetta, which are rather more recent than the Chalk. By Ehrenberg's figures it appears that in gatherings of recent Diatoms from all parts of the world in every possible variety of climate, the majority of species are identical with our own. Diatoms, therefore, are not materially affected by existing differences of climate, and have probably been as little affected by the geological changes which have occurred, at all events, since the period of the Eocene deposits.

We now turn for a moment or two to the geological importance of Diatomaceæ in the formation of strata. Ehrenberg observes: "Siliceous infusoria occasionally form in stagnant water during hot weather a porous layer of the thickness of the hand. Although more than 100,000,000 weigh hardly a grain, one may in the course of half an hour collect a pound weight of them. Hence it will no longer seem impossible that they may build up rocks." Dr. Hooker, in a paper read before the British Association in 1847, says, "the waters, and especially the new-formed ice, of the whole Antarctic Ocean between the parallels of 60° and 80° south, abound in Diatomaceæ so numerous as to stain the sea everywhere of a pale ochreous brown, the surface having that colour as far as the eye can reach from the ship. Their death and decomposition produce a submarine deposit, or bank, of vast dimensions, consisting mainly of their siliceous shields intermixed with Infusoria and inorganic matter. Its position is from the 70th to the 78th degree of south latitude, and it occupies an area 400 miles long by 120 miles wide. The lead sometimes sunk two feet into this pasty deposit, and on examination showed that the bottom was made up in a great measure of the species now living on the surface. This deposit may be considered as resting upon the shores of Victoria Land, and of the Barriers, and hence on the submarine flanks of Mount Erebus, an active volcano of 12,000 feet high. From the fact that Diatoms and other organisms enter into the formation of pumice and ashes of other volcanoes, it is perhaps not unreasonable to suppose that the subterranean and subaqueous forces which keep Mount Erebus in activity may open a direct communication between the diatomaceous deposit and its volcanic fires. Moreover, this bank flanks the whole length of Victoria Barrier, a glacier of ice 400 miles long, whose seaward edge floats in the ocean, whilst it landward extends in one continuous sweep from the crater of Mount Erebus and other mountains of Victoria Land to the sea. The progressive motion of such a glacier, and accumulation of snow on its surface, must result in its interference with the deposit in question, which, if ever raised above the surface of the ocean, would present a stratified bed of rock which had been subjected to the most violent disturbances."

The mud of the Thames, excluding the coarse sand, contains nearly one-fourth its mass of the siliceous valves of different species of Diatomaceæ, mostly marine forms. Ehrenberg states that in the mud of the Elbe, at Glückstadt and above Hamburg, respectively forty and eighty miles above the mouth of the river, many siliceous shelled Infusoria are found alive, and their skeletons deposited in such abundance as to form nearly one-third the entire mass. His examination of the mud of the Scheldt furnishes similar results. He considered that at Pillau there are annually deposited from the water from 7,200 to 14,000 cubic metres of fine microscopic organisms which in the course of a century would give a deposit of from 720,000 to 1,400,000 cubic metres of infusory rock.

To state the bearing of these facts upon past changes. The River Columbia in its course at Place du Camp runs between two precipices, 700 to 800 feet high, composed of porcelain-clay 500 feet thick, covered over by a layer of compact basalt 100 feet thick, on which again some volcanic deposits exist. The clay strata are of very fine grain, and vary in colour, some being as white as chalk. Dr. Bailey has shown, from some portions submitted to him by Colonel Fremont, that this apparently argillaceous deposit is entirely composed of freshwater Infusoria. Its perfect purity from sand shows that it is not a drift, but has been formed on the spot. By its immense thickness of 500 feet this layer of Biolithic Tripoli far surpasses any similar layer elsewhere, in which the thickness is ordinarily one or two feet, although those of Luneburg and Bilin have a depth of 40 feet.

A very fine diatomaceous deposit has been found by Dr. Gregory in the Island of Mull; when dry, it is almost white, and much resembles chalk, and is almost entirely composed of siliceous remains for the most part entire. Similar examples are found in our own country on the ancient site of a mountain-lake in the neighbourhood of Dolgelly, near Lough Island, Newry, County Down, and Lough Mourn, in Ireland. At Oran, in Algiers, a similar deposit also occurs.

Bergmehl, Tripoli, and other polishing powders, the stratified deposits at Bilin, in Bohemia, and in Ægina, with others, might be adduced to demonstrate the important part played by these minute beings, when accumulated in countless myriads, in the construction of the earth's crust. And further, Ehrenberg states, that species of Diatomaceæ are found in the Oolitic and even in the metamorphic and porphyritic rocks, although the most are found in the Pliocene, Miocene, Eocene Tertiary deposits, and in the Chalk and Flint. Vast though the periods of time which must have elapsed in the formation of these deposits, and mighty though those convulsions were that broke up, distorted, and mixed them together,—still we find that their specific types remain, and that in the pellucid pools of the moor, or amid the varied animal and vegetable products of the sea-bottom, living and flourishing at the present day, are found the same forms identical in outline, markings, and size with those that have lain buried for ages many hundreds of feet below them. In this part of the earth's history, at any rate, species have remained constant, and there has been no variation of form and most probably none of habit.

A few words as to the uses of these deposits will conclude this note. Facts go to prove that soils wherein Diatoms abound are above the average in fertility; and the large amount of silica required for cereal crops point out that probably deposits of mud or even older strata, when properly prepared, would add materially to the efficiency of manures. Accordingly, in Jutland, a blue sand abounding in calcareous and siliceous shells is collected and greatly increases the fertility of the arable soil to which it is applied; and Professor Bailey states that the mud of Newhaven harbour is used as a fertilizer, and is found to contain 58·63 per cent. of silica. He also adduces proof that the great fertility of the rice-fields of South Carolina is mainly due to their richness in diatomaceous remains.

In the arts the remains of diatomaceous shells are brought into use as polishing powders under the name of Tripoli, and also as an extremely fine and pure siliceous sand in the manufacture of porcelain.

Permit me to add that it is in the power of Members to follow out the subject by contributing specimens of deposits to this Association. A very small quantity of the dust or small particles obtained when cleaning fossil specimens, put into a paper and labelled with the locality where found, and the name of the deposit and of the fossil from whence obtained, would often yield, when submitted to a microscopist, some important information, or perhaps even species unknown to science.

"Microscopic Geology. Note 3: Foraminifera."* By Mr. W. Hislop, F.R.A.S.

If we walk on a sandy shore at low water during fine weather, when the sea has receded with a gentle ripple, we shall find the ripple-marks very distinct. Between rocks and in quiet coves we observe these marks traced out with lines of minute bodies, like white sand. These bodies, when taken up and examined by the microscope, will prove to be mostly composed of very small white shells, very similar in general form to Nautili.

During those interesting investigations into the character of the bottom of the ocean, undertaken some time since, it was necessary to take soundings of its deepest parts. The leads used for the purpose were so contrived as to bring up portions of the bottom upon which they struck. In this way specimens were obtained from a depth of nearly 2,000 fathoms, which proved on examination to

* Read before the Association on 7th February, 1865.

be mainly composed of minute shells, of a similar kind to those found on sandy shores at low water.

The sand which is found in boxes or drawers in which the common sponge of commerce is kept generally yields a large quantity of these beautiful pearly shells. Examination of these shells by the microscope reveals some peculiar features. While bearing a general resemblance to the Nautilus, we notice that, unlike that or any other shell, there is no mouth or other large opening from which the animal may protrude its feeding or its locomotive organs. We also observe that almost all the shells are covered with minute dots, which subsequent observation will show to be holes. Hence the name Foraminifera has been given to this group of organisms.

To understand the economy of these creatures we must for a moment glance at the living animal. If we look closely at the seaweed growing in an aquarium in good order, we shall probably see a number of white specks adhering to some of them, and also to the sides of the tank. These are probably Foraminifera, and the application of the hand-lens most likely shows the species to be *Polystomella crispa*, about $\frac{1}{30}$th of an inch in diameter. We must now carefully remove some of these shells to the live-box of the microscope, and leave them for a few moments to recover themselves. Careful observation will now show us protruding from the specks or orifices, tiny points of a clear gelatinous substance. These very slowly extend, and stretch out to a considerable distance on either side of the shell. The slightest disturbance or concussion causes their withdrawal, but they will be again protruded when all is quiet. These threads are called pseudopodia. By their adhesion to surfaces and by contraction, the animal can draw itself along, and thus change its position. They are also probably the means whereby it feeds upon very minute animalcula, or other substances floating in the water. The organization of the animal inhabiting the shell is very simple. Foraminifera are almost exclusively marine, but a curious organism found in fresh water will serve to illustrate their structure. This is the *Amœba*, a minute mass of transparent jelly, which has the power of altering its shape to any extent. This mass of sarcode, as it is termed, obtains nutriment by attaching itself to the substance on which it is to feed, and enveloping it with its own body, any part of the surface of which seems to have the power of absorbing the nourishment required, the indigestible portions being subsequently rejected by evolution.

The shell of the Foraminifera is occupied by a similar mass of sarcode, which has the power of protruding itself through the openings of its shell, as already described, and thus forming the pseudopodia, which possess the power of attaching themselves to the required food, and probably either assimilating it at once, or drawing it within the body of the animal for subsequent digestion.

The Foraminifera are very widely distributed through the known strata of the earth's crust, but have accumulated to such a vast extent in some of them, that certain beds are almost entirely composed of aggregations of the species *Miliola*, and are known as Miliolite Limestone. Foraminifera are also particularly abundant in the Tertiaries of the Paris basin; but in England we know them best in the Upper Chalk. So numerous are they here that some have supposed that the deposition of that immense mass is chiefly due to their agency. The best method of finding them is to scrape a small quantity of the Chalk to be examined very finely with the penknife, and after moistening it with turpentine, to let a drop of Canada balsam fall on it, warming it at the same time over a lamp. Being now covered with a piece of thin microscopic glass we may soon ascertain whether we have been successful in obtaining specimens.*

One great feature of interest to the geologist, as in the case of the Diatomaceæ, is that probably a large proportion of early forms are the direct lineal descendants of species belonging to very remote geological periods. Ehrenberg pointed out that their shells occasionally undergo an infiltration of silicate of iron, that completely fills the interior of the shell to its minutest ramification; so that, if the shell itself is decomposed, a perfect internal cast remains of the original body of the animal. He has also shown that the green sands which present themselves in various geological formations, from the Silurian system upwards, are in great part composed of these casts; and it has since been shown by Professor Bailey that a

* Mr. Cresy suggests that whiting-maker's sand, which is the deposit left after washing the Chalk, is exceedingly productive in Foraminifera.

similar infiltration is taking place over certain portions of the ocean-bottom, and that beautiful internal casts are obtainable by treating with dilute acid foraminiferous shells, whose cavities have been thus filled.

But recent evidence has been obtained that foraminiferous shells are to be found in that immense series of rocks below the Silurians, which have hitherto been called "azoic," as being destitute of the evidences of animal life. During the progress of the labours of the Geological Survey of Canada, under the direction of one of our honorary members, Sir W. Logan, there were found in the year 1858, sixteen bands of limestone in the Lower Laurentian formation, one of the oldest of granitic rocks. In these bands were discovered certain flattish rounded masses, which seem to be of organic origin. Dr. Dawson, of Montreal, examined them under the microscope, and declared them to be Foraminifera, and gave them the name of *Eozoon Canadense*, or the Dawn-animal of Canada.

Not long since a paper was read by Dr. Carpenter before the Royal Society, who confirms Dr. Dawson's general conclusions, and identifies among living Foraminifera the species most like the ancient form. His deductions are drawn from a minute microscopic examination of the fossil form, and he remarks, "I cannot refrain from stopping to draw attention to the fact that the organic structure and the zoological affinities of this body, which was at first supposed to be a product of purely physical operation, are thus determinable by the microscopic examinations of an area not larger than a pin-hole, and that we are thus enabled to predicate the nature of the living action by which it was produced at a geological epoch, whose remoteness in time carries us back even beyond the range of the imagination, with no less certainty than the astronomer can now by the aid of spectrum-analysis determine the chemical and physical constitution of bodies whose remoteness in space alike transcends our power to conceive."

May I be permitted to observe in conclusion that the value of the microscope in geology could not have received a stronger confirmation; and it can hardly be doubted that further discoveries in geology await the investigation of those who bring to their aid the developments of other sciences. The greatest results are to be attained by those who do not confine their attention to one department alone, but seek to read the hieroglyphics of nature by the wonderful lights of science.

Ordinary Meeting, May 3rd, 1864.

E. Cresy, Esq., President, in the Chair.

The adjourned discussion on Mr. Mackie's paper was reopened by Mr. Mackie, who briefly recapitulated the chief points of his argument. A prolonged and interesting discussion ensued, in which many of the members joined. Remarks were also made by Professor Macdonald and other visitors.

Mr. E. Ray Lankester exhibited a fine specimen of Pteraspis discovered by him at Cradley, Hereford.

Ordinary Meeting, June 7th, 1864.

E. Cresy, Esq., President, in the Chair.

The following papers were read:—

No. 1.—"On the Excursion to Sevenoaks." By Mr. C. Evans.

On Easter Tuesday, the 29th of March, the first excursion of the Association for this season was made to Sevenoaks, in Kent, for the purpose of examining the geology of the extensive railway-works now being carried on in the neighbourhood of that town by the South-Eastern Railway Company.

On arriving at the Sevenoaks Station of the London, Chatham, and Dover Railway, the party, consisting of 23 gentlemen, proceeded along the road, through the town to the escarpment of the hill at Riverhill, whence a very fine view of the valley of the Weald of Kent was obtained. The members, after descending the hill for a short distance, struck across some fields to the shafts at the south end of the long tunnel just commenced. Advancing from this point in a north-westerly direction along the line of the railway-works, they examined in the first place the materials thrown out at the various shafts, and afterwards the open cutting at the northern end of the tunnel, some of the party extending their walk along the railway embankment and cuttings as far as Riverhead.

Having on a previous occasion given some description of these railway-works, I find that I have now very little to add with regard to the local geology of Sevenoaks to the account which I have given in my former paper. Under these circumstances I purpose on the present occasion to digress somewhat from the proper subject of this paper, and, while alluding to the principal facts which were noticed on the occasion of the excursion, to give you in addition *a general sketch* of the geology of the South-east of England derived principally from the various published works on the Cretaceous and Wealden beds, hoping thereby to excite in some of those now present sufficient interest in the subject to induce them either singly or in company again to visit this and other sections around the escarpment of the Weald, and to assist, as far as the time at their disposal will allow, in elucidating the many interesting questions with regard to these formations which yet remain unsolved.

The oldest strata that are met with at the surface of the country in the South-east of England consist of those remarkable fresh-water or fluvio-marine deposits, underlying the Cretaceous formation, which are known as the Wealden beds, since they are for the most part coextensive with, though not restricted to, the district known as the Weald of Kent, Sussex, and Surrey. The Wealden beds occupy a rudely elliptical area, a portion of which, separated from the rest by the British Channel, forms the surface of a small part of the North of France. The Wealden district is surrounded on every side by hills composed of the Cretaceous deposits. These Wealden beds are exposed at the surface of the country in consequence of a great fold or anticlinal axis, which extends through the middle of the district, by reason of which the various beds have been elevated into a curve of wide extent, and the upper members have subsequently been denuded from off the central portion of the area. A similar but smaller valley of elevation is seen in the

Isle of Wight, the central axis of which extends from Brook to Sandown Bay, and there also the Wealden beds are seen at the surface. On each side of these central axes the beds dip in opposite directions, those on the south side having an inclination to the south, and on the north side to the north. Sevenoaks being situated on the north side of the main anticlinal, the strata in that district in general dip to the north.

The Wealden beds have been subdivided into two groups. The lower of these groups, known as the Hastings Sands, consists for the most part of sand, calcareous grits, and clays, and forms the range of hills which extends in an east and west direction from Hastings to near Horsham. The upper group, the Weald Clay, consists of clays with occasional bands of limestone called Sussex, Petworth, or Bethersden Marble. It occupies the broad valley which intervenes between the central range of hills and the range composed of the Kentish Ragstone, one of the lowest members of the Cretaceous formation.

The Hastings Sand-beds are well seen in the fine cliffs in the neighbourhood of the town from which they take their name, and also in the various quarries along the inland range of the series now celebrated as having afforded to the late Dr. Mantell the remains of the Iguanodon and other reptiles of gigantic size.

The division of the Weald Clay is seldom well seen in Kent or Sussex, as no cliffs composed of it are met with on the coast. It forms, however, a considerable part of the cliffs in the Isle of Wight, between Atherfield and Compton Bay. This bed is the lowest worked through in the new railway-works at Sevenoaks, and the members have now a very favourable opportunity of examining the character and of collecting the fossils of this deposit.

Around the several shafts on the low ground at the foot of Riverhill the spoil-heaps show that the deposit consists of beds of blue and green clay, with a band of hard crystalline limestone, composed for the most part of the shells of freshwater univalves and bivalves (Paludina and Cyrena). The same shells are found in abundance on splitting the masses of clay, together with freshwater mussels (Unio), Cyprides in great numbers, and the scales of Fishes.

The Weald Clay is also seen around five of the shafts at the top of the hill, but in these upper beds the fossils do not appear to be so abundant. No trace is seen here of the band of marble, which has probably dipped below the level of the Tunnel. At some of these latter shafts blocks of an argillaceous limestone are brought up, some of which contain many small univalve and bivalve shells, while others show on their edges very thin bands, apparently containing many minute black grains. These black grains are the shells of a tuberculated species of Cypris in fine preservation, which stud the surfaces in great numbers; other species of Cypris are seen in the lower layers of the clay.

The Weald Clay is succeeded by the Lower Cretaceous deposits.

These latter beds, usually known as the Lower Greensand, consist of sandstones, limestones, and sands, either white, green, or ferruginous, and are succeeded by the thick bed of clay known as the Gault, which occupies the valley separating the Greensand hills from the high range of the Chalk downs. Of the Lower Greensand division of the Cretaceous formation we have three fine natural sections, namely, the one extending from Hythe to Folkestone, the one in Sandown Bay, from Redcliff to Shanklin, and the one at Atherfield and Compton Bay. Of these the one from Atherfield to Blackgang Chine is the most complete, since, on favourable occasions, the whole series of beds from the Weald Clay to the Gault may be seen in uninterrupted sequence. Dr. Fitton, our principal authority with regard to these beds, has in his admirable memoir on the strata between the Chalk and Oxford Oolite taken as his typical section the one from Hythe to Folkestone; and, having subdivided the Lower Greensand, as there seen, into three groups, he endeavoured to trace those subdivisions throughout the inland range of the series. His groups are as follows: 1st. An upper division, consisting for the most part of white, yellow, and ferruginous sands, with occasional concretions of limestone and chert. 2nd. A middle division containing more clayey beds, abounding in green matter, often of a marshy character, and containing comparatively little stone, and 3rd. A lower division containing the principal beds of building-stone or Kentish Rag, which in general forms a ridge of hills overlooking the Weald.

The section at Atherfield (subsequently described in detail by Dr. Fitton) differs from the one at Hythe, not only in the greater thickness of the whole series (800 feet), but also in the fact that there is no appearance at Atherfield of regular bands of stone in any part, the deposits consisting throughout of alternations of clays and sands, with occasional concretions. This section is also remarkable for the highly fossiliferous beds which rest immediately on the freshwater Wealden deposits. These beds, known as the Perna-bed and the Cracker-nodules, were at first considered as unrepresented elsewhere in England.

After the publication of Dr. Fitton's original memoir, Mr. Godwin-Austen described a section in the neighbourhood of Guildford, somewhat intermediate in character between those of Hythe and Atherfield. In this paper Mr. Austen also divided the Lower Greensand of Guildford into three groups, viz., an upper and ferruginous division, a middle division containing the Bargate Stone and Kentish Rag, and consisting of sands with subordinate bands of siliceous building-stone, and an argillaceous division, to which he applied the term "Neocomian," consisting of brown and yellow clays containing nodular concretions of great size and thickness abounding in corals and shells. The most remarkable features in the section at Guildford, as described by Mr. Austen, is the absence of any equivalent to the "middle division" of Dr. Fitton, and the presence there of the very fossiliferous Neocomian division, the equivalent apparently of the Perna-bed, and perhaps of the Crackers of Atherfield.

This Neocomian division—the junction-bed between the Wealden and the Lower Greensand—was subsequently recognised on the South-Eastern Railway at Red Hill, on the Maidstone branch of the same railway near Wateringbury, and in a shaft sunk through the Kentish Rag beds near Hythe. A similar bed was observed on the Portsmouth Railway, near Haslemere; and Mr. Bensted has described a marine fossiliferous clay as underlying the stone beds in his quarry at Maidstone, and resting on the Weald clay. At all these places it is found to contain fossils in abundance. This bed has not to my knowledge been observed in other localities, owing probably to the fact that it rests immediately on the Weald

Clay, resembles it closely in mineral character, and, like it, crops out in the low ground at the foot of the Greensand hills.

It is, therefore, very interesting to find that a similar bed was passed through at several of the shafts at the top of the hill at Sevenoaks. It was found to consist there of a dark-coloured sandy clay (with much water), abounding in specimens of Arca, Corbula, and many other fossils similar to those from the Neocomian bed of the other localities mentioned above. Some portions of the bed are concreted and contain the remains of a large Perna.

Unfortunately, at the time of the visit of the Association, the works at the shafts where the deposit was seen last autumn had been carried down to the Weald Clay, while the more northern shafts had not been sunk below the Kentish Rag, in consequence of which very little of this, the most fossiliferous bed at Sevenoaks, was to be seen on that occasion; sufficient however was exposed to enable several of the members to supply themselves with specimens of the deposit, and some of the more characteristic fossils.

The Neocomian bed is succeeded by the Kentish Rag series, the "lower division" of Dr. Fitton.

Throughout the greater portion of Kent this division forms a range of hills (broken, however, by the transverse river-valleys), which runs in a parallel direction to that of the Chalk Downs. This series is best seen in the quarries at Hythe, Maidstone, and other places, where it consists of alternations of bands of limestone more or less compact or crystalline, with layers of chert and a soft light-coloured sandstone full of grains of green earth, locally known as "hassock."

The calcareous matter of these stone beds appears to diminish in the western extension of the series; and in several places in Surrey, as, for instance, at Red Hill, the lowest beds consist of sands and soft sandstone, with occasional concretionary blocks of stone. In the western districts beds of stone occur in a position rather higher in the series, as, for instance, on the top of the hill at Nutfield, where a soft building stone is found associated with local beds of fullers' earth. In the neighbourhood of Guildford a building-stone, consisting of a conglomerate more or less compact, which is there known as Bargate Stone, occupies a similar position. The Bargate

Stone bands are associated with coarse pebbly sands. Traces of pebble-beds are to be seen at Dorking, Nutfield, and Folkestone, and probably elsewhere.

The absence in the Isle of Wight of regular bands of stone renders it difficult to identify the equivalent of the Kentish Rag series at Atherfield and Sandown Bay.

At Sevenoaks this part of the section presents the usual appearance of the Kentish Rag series in Kent, consisting of alternations of limestones, sandstones, and chert, blocks of which are seen around the more northern shafts of the tunnel; at the north end of the tunnel a very fine section of the lower beds of the series is well seen.

The most remarkable feature in this part of the section is a saddle or anticlinal axis, through the top of which the railway cutting has been formed for about half a mile, the beds on the one side dipping to the south-east, and on the other to the north-west. In the low cutting near the mouth of the tunnel a complete arch of the beds is seen. The beds are also much faulted at this spot.

Folds or minor anticlinal axes are described as occurring in the Lower Greensand beds at several other places. One is noticed by Dr. Fitton as exposed at Sundrish, a short distance to the west of the railway-section at Sevenoaks. Another is seen at Tilburstow Hill, south of Godstone; and another, passing across the district to the south of Guildford known as the Peasemarsh, has exposed the whole of the series from the ferruginous sands to the Weald Clay.

One of the commonest fossils in this group is the large *Gryphæa* or *Exogyra sinuata*, which I have met with at Hythe, Maidstone, and Sevenoaks; it is also very abundant in the central portion of the Lower Greensand at Atherfield and Shanklin.

Another common fossil is *Terebatula sella*, which at Atherfield occurs in bands associated with the "ranges" of Gryphæa sinuata. I have not as yet observed this shell in the Kentish Rag division at Sevenoaks, although it is there abundant in the Neocomian bed.

Two or three species of *Trigonia*, together with other bivalves, are found in some of the beds, but mostly in the form of casts. A small Belemnite also appears to be common in this part of the series.

One other shell I may mention, viz., the *Terebratula* or *Terebratella oblonga*, a brachiopodous shell characterised by several strong ribs or striations and other points of distinction. It has been found in the Kentish Rag series, and the same or a closely allied shell also occurs in the Cretaceous conglomerate and pebble-beds at Badbury Hill, near Farringdon. It is a rare shell in most localities.

I was much interested, therefore, on finding last autumn, near the shafts at Sevenoaks, several blocks of sandstone or Hassock, which I believe, from the position in which I found them, came from near the top of the Kentish Rag series, and which contained *Terebratella oblonga* in abundance, associated with a species of *Plicatula*.

The Kentish Rag division is succeeded at Sandgate by a remarkable bed, which, where seen in the undercliff between Sandgate and Folkestone, appears as a dark-coloured sandy clay, without any conspicuous bands of stone or concretions. It is between 70 and 100 feet thick, and was described by Dr. Fitton as the "middle division" of the Lower Greensand. In the inland sections of these beds Dr. Fitton describes this middle division as occupying flat and marshy ground, separating the hills composed of the upper division from those of the Kentish Rag. He also stated that this dark bed, though nearly 100 feet thick at Sandgate, thins out to the west.

Although I feel that I am setting my opinion against those of geologists who have given much more attention to the Lower Greensand than I have myself, I must observe that it appears to me, from several facts which I have noticed, doubtful whether this middle division of Dr. Fitton is entitled to rank as a natural group of equal value to the Kentish Rag or the Neocomian bed.

Although a valley is seen in many places to the north of the Kentish Rag hills, and separating them from the ferruginous sands of the Upper Division, such a valley does not appear to be continuous throughout the whole range of the formation around the Weald; and where one is present it does not always appear, as far as can be seen in our imperfect inland sections, to occupy precisely the same position in the series in different localities. Thus at Sevenoaks the line of railway, on emerging from the cutting before described, passes by means of an embankment over low wet ground until it reaches the cutting through the ferruginous sands. But this valley is not continuous throughout the district, but appears to be only a small diagonal valley descending from the Ragstone hills, since an observer may advance along the road from the present railway-station on the ferruginous sands, up the hill through Sevenoaks, to the escarpment of the Kentish Rag, without the intervention of any valley.

The clearest inland section of this part of the series with which I am acquainted is the one seen in descending the hill on the south side of Saint Martha's chapel near Guildford. Here the ferruginous sands are only separated from the lower sands which rest on the Neocomian bed by bands of Bargate Stone and pebbly sands, and thin bands of fullers' earth.

It is, I believe, generally found that pebble-beds have a considerable horizontal range, and I have before observed that pebbly bands have been noticed in the Lower Greensand at several spots in the range of these beds from Guildford to Folkestone. Thus at Nutfield, Surrey, pebbly sands are seen below the fullers' earth and the associated beds of soft building stone (which by the way contains a small Avicula common also in the Bargate Stone), and certainly below any beds which, as represented in Dr. Fitton's section, intervene between the fullers' earth beds and the ferruginous sand, and occupy the low ground to the north of Nutfield.

Any pebble-beds which I have observed at Sevenoaks also occur at the top of the Kentish Rag cutting; while at Folkestone pebble-beds, also containing in abundance the Avicula of Nutfield and Guildford, are found *above* the dark clayey bed of Sandgate.

If we may assume that these pebble-beds are continuous throughout the district from Guildford to Folkestone, it results that the beds considered by Dr. Fitton as representing his middle division are not present at Guildford, are above the pebble-beds at Nutfield and Sevenoaks, while the typical bed at Sandgate is below them.

The upper division of the Lower Greensand consists for the most part of white, yellow, and ferruginous sands.

At Folkestone, where these beds are well seen in the cliffs, they differ somewhat from the equivalent beds elsewhere in containing many bands of concretions of limestone and chert, and in being very slightly ferruginous.

At many places along the north side of the Weald, and also in the Isle of Wight, these beds consist of loose sands, occasionally ferruginous, and containing irregular veins of pebbly ironstone; and this is their condition in the neighbourhood of Sevenoaks. This division usually exhibits much cross-bedding.

The upper part of the Lower Greensand contains very few fossils, especially if we separate from it the Bargate Stone of Guildford and the beds associated with the pebbles at Sandgate. I have not found any trace of shells in the ferruginous sands at Sevenoaks.

Casts of shells occur in ferruginous sands at Shanklin; but they have been found in greatest abundance in concretions occupying a low position in the Upper Division at Parham Park, in Sussex.

The ferruginous sands pass under the thick clay bed of the Gault. The Gault passes into the Upper Greensand, and the latter into the Chalk-marl and Lower Chalk.

The Gault occupies the valley at the foot of the Downs, and presents the same mineral character throughout the whole of its range, and, where exposed, contains similar fossils to those so abundant in it at Eastware Bay, near Folkestone.

The Upper Greensand is thin, and seldom exposed in Kent; but in parts of Surrey and Sussex it contains beds of stone locally known as Firestone or Malm-rock. It increases in thickness in its progress westward; and in Dorsetshire, Devonshire, and Wiltshire it contains thick bands and concretions of chert. The Gault and Upper Greensand have not as yet been exposed in the railway-works at Sevenoaks.

I have entered so far into the details of the geology of the country around the Wealden escarpment, in the hope, as I before remarked, that others of the members will from time to time give some attention to an interesting group of deposits which, judging from the published papers on Geology, have not, during the last twenty years, received as much attention as several others of the Secondary formations. I will, therefore, conclude by alluding briefly to some of those points of interest to which the attention of members may be most profitably directed.

In the first place, the Weald Clay is one of those freshwater deposits formed of the spoils of adjacent land, in which we may search with the greatest chance of success for additional facts tending to throw light on the character of the old "country of the Iguanodon."

The Iguanodon is itself very imperfectly known, and still less is known of the various other animals, and of the plants which were its contemporaries. A few specimens picked up or obtained from the men for trifling sums might throw much light on doubtful points as to these subjects.

No Mammalia have hitherto been met with in the Wealden beds; and, although I am not prepared to state that they are to be found in the Weald Clay, yet it is quite possible that a continued examination of this deposit might result in the discovery of some of these most interesting remains, since several species of Mammalia have been discovered in the freshwater Purbeck beds below the Wealden.

The junction of the Lower Greensand and the Weald Clay is a subject also well worthy of further attention.

I have before stated that the deposit which I have termed the Neocomian bed has only been observed at a few places around the Weald; notices of any additional places where it may be seen would therefore be of great value.

As this is the most fossiliferous of the Lower Greensand beds at Sevenoaks and elsewhere, many additions to our lists of British fossils may, doubtless, be met with in it; thus enabling us to determine whether this junction-bed is truly the equivalent of the Neocomian beds of the Continent.

Although, in general, the fossils of the Kentish Rag are not well preserved, there are many points well worthy of attention with regard to this division of the series; and I may remind the members that the most instructive specimen of the Iguanodon at present known was obtained from Mr. Bensted's Ragstone quarry at Maidstone.

The exact equivalent at Atherfield of these beds has yet to be determined, for which purpose the change of mineral condition of the stone beds as they trend to the west, should be traced as far as possible.

I have already mentioned the doubtful character of the Middle Division of Dr. Fitton. For the purpose of solving this question, the dark Sandgate bed should be traced as far as possible inland, the material occupying any of the valleys intervening between the Kentish Rag and the ferruginous divisions should be noted wherever practicable, and endeavours should be made to determine whether the pebble-beds of Guildford, Nutfield, and Folkestone are continuous throughout the district. Diligent search should also be made in these pebble-beds for drifted fossils, as Mr. Meeier has formed a very fine collection of drifted teeth, &c., from the pebble-beds of Guildford and Godalming.

Fossils of the upper beds of the Lower Greensand, being rare, should be carefully preserved and accurately determined (if possible), in order to ascertain whether the organic remains of this part of the series present a closer (per-centage) relation to those of the Gault and Upper Greensand than do those from the lower members of the formation.

Neither should the study of the Gault and Upper Greensand be overlooked, since on the knowledge of the various beds of the Middle and Lower Cretaceous rocks depends greatly the solution of questions with regard to the age of some interesting deposits in the North and West of England.

One of these outlying deposits is a clay bed, seen in the cliffs at Speeton, in Yorkshire, which is said to contain an admixture of forms elsewhere considered peculiar to the Oolite or the Greensand.

The Red bed at Hunstanton, in Norfolk, has already been described before the Association, but its age is still doubtful; by some it is considered as the equivalent of the Gault, while others look upon it as of Upper Greensand age.

Outlying deposits of pebble-beds and conglomerates occur in the neighbourhood of Farringdon, and are known as the Farringdon Sponge-gravels, as very beautiful Sponges are abundant in them. Although now very generally considered to be of the age of the Lower Greensand, the late Mr. Daniel Sharpe, a great authority, believed these Farringdon gravel-beds to be of more recent date than the Chalk itself, though still belonging to the Cretaceous period.

Another very interesting subject is the age of the Whetstone beds of the Blackdown Hills, in Devonshire, in which deposits fossils of the Lower Greensand, Gault, and Upper Greensand, beautifully preserved, although completely silicified, seem to be curiously intermixed in such a way as to make the age of the bed very doubtful. In our London museums these fossils are arranged as Upper Greensand. Mr. D. Sharpe considered them of the age of the Gault, and a few geologists have classed them as Lower Greensand.

Time will not permit me to enlarge at present on these questions, but I hope on some future occasion to bring this branch of my subject before you in greater detail, and in the meantime I trust that other members will come forward, and give us some local papers on the Middle and Lower Cretaceous formations.

No. 2. "Notes and Queries on Geological Subjects." By Mr. G. E. Roberts, F.G.S.

After the reading of the paper, it was proposed that "Notes and Queries" should be periodically published by the Association, and that the paper just read form the first number.*

Ordinary Meeting, July 5, 1864.

E. Cresy, Esq., President, in the Chair.

The following papers were read:—

No. 1. "On a Recent Marine Deposit at Boulogne." By Mr. C. B. Rose, F.G.S.

On returning from Paris in the spring of 1862 I slept one night at Boulogne, and on the following day I made a hurried examination of the harbour, piers, &c. In so doing I met with a hillock of sand and débris, enclosing Cardia, Mytili, and other shells, clearly such as inhabit the adjoining sea.

This circumstance haunted me on my return home so much as to

* Mr. Roberts's "Notes and Queries" have been printed and circulated amongst the members.

induce me to propose to my friend Mr. Wiltshire a revisit on my own part to Boulogne, accompanied by him. He readily assented, and very soon we were on our way. Arriving there about three p.m., and after taking care of the inner man, we proceeded in search of *my* recent marine, which I had no difficulty in finding, and to exploring we went. My friend's piercing and more practised vision not only detected the Cardia and Mytili, but to my dismay fragments of bricks, tobacco-pipes, and soles of dilapidated shoes, proving that it was indeed a *recent* accumulation.

Not discouraged by this discovery, I looked about me for something to repay us for what now appeared to be a wildgoose-chase after a mare's nest: and on going down into the excavation now in progress for the formation of a new basin or dock, we came upon a really recent marine deposit. The dock, when completed, will occupy 70 English acres of ground; in forming it they have opened a bed of sea-sand to a depth of 30 feet, and found that it reposed upon a stiff clay, the Kimmeridge, into which they entered six feet, and which they determined should form the floor of the dock. From the sand we collected a number of shells, a list of which I will append to this paper. Wishing for more information upon the subject, I wrote to M. Bouchard-Chantreux, an eminent naturalist and geologist,* who obligingly informed me that the Lower Town of Boulogne stands upon this sandy deposit, for upon breaking ground to lay the drainage-pipes, they invariably open this bed of shells. He also informed me that this arenaceous deposit containing shells extends along the valley of the Liarne up to St. Omer, a distance of 38 miles. M. Bouchard has collected similar shells at that town. From the same gentleman I learnt that at various spots in the above valley a fluviatile deposit containing Limneæ, Cyclades, Succineæ, and Helices has been found lying above the marine deposit. There appears to have been a subsidence of this part of the French coast since the Roman period; for during the occupation of France by the Romans, as I am informed by M. Bouchard, their legions collected the septaria and shaly portions of the Kimmeridge Clay

* Recently deceased, and who at my visit possessed a very fine collection of Kimmeridge and other organic remains.

at low tide to form the kerb-stones to their military roads at spots now covered by more than twenty feet of beach-sand.

And now let me account for the *hillock* of heterogeneous matter (bricks, pipes, &c.), the cause of my second visit to Boulogne. It will be seen by the plan that it lies near the *small* basin, the history of which basin is the following. In 1803 Napoleon I. had it excavated for the reception of his flotilla assembling there to be ready for the transport of his army collected on the heights adjoining the town, for the invasion of England. Nelson was foiled in his attempt to destroy the flotilla, but at the battle of Trafalgar he saved his country the horrors of invasion by destroying the combined fleets of France and Spain. Such is the origin of the strange accumulation of apparently incompatible materials which led to a very agreeable trip with my friend the Rev. Thos. Wiltshire.

I lay before you a specimen of each kind of shell we collected from the sand, and I append a list of them :—

Cardium edule.
Mytilus edulis.
———— var. incurvatus.
Lutraria compressa.
Mactra solida.
Patella vulgata.
Litorina litorea.
——— litoralis.
Tellina solidula.
——— tenuis.
Donax anatinus.

2nd. "On the Excursion to Bromley." By Mr. A. Ramsay, Junr.

In accordance with the arrangements made by the Committee, a party of our Members made an excursion to Bromley on the afternoon of Saturday, the 18th of June. On arriving at the Bromley Station we were received by Mr. Ilott, who, after drawing our attention to the section of gravel at the station, escorted us to his house, where he had arranged for our inspection a series of fossils, mostly from the strata in the neighbourhood. From his house we proceeded by a field-walk to Elmstead Lane, a distance of about two or three miles, during which we interchanged a few words of antiquarian gossip.

Geology and archæology so intermingle with one another that it is difficult to say where the one ends and the other begins. The information afforded by the names of places does not extend to a period very far removed from the present, still it sometimes has a little to do with geology. Bromley is from the Anglo-Saxon words *Brom* and *leag*, which mean the district where broom grows. In Chiselhurst we see evidences that our Anglo-Saxon ancestors had noticed one of the marked geological features of the district. In the language used by them a flint or pebble was called *ceosel*, which has become transformed into *chisel* in our modern geographical orthography. Chiselhurst then means the pebble-wood, referring, doubtless, to the great abundance of black pebbles which cover the ground; so in other counties, we have Chiselborough in Somersetshire, Chisledon and Chiselbury Camp in Wilts, Chiselbourne, Chiseldon, and the Chesil Bank in Dorsetshire. I would ask whether all these are connected with any pebbly characteristics in the localities; the last, we know, is what its name implies, a pebble-bank, and the previous name is that of a town or rather village which marks the commencement of that remarkable collection of stones. This would suggest the inquiry whether the pebble-beds round Bromley are the remains of a similar bank on the shores of the old Eocene sea.

At Elmstead Lane we visited the pit in Sundridge Park, where there is a fine section of what was formerly called the Plastic Clay, but which, since the admirable memoir by Mr. Prestwich in the volume of the Geological Society's Journal for 1854, has been called the Woolwich and Reading Beds, which are the oldest Tertiaries in this country, with the exception of the Thanet Sands. The strata of which they are composed are remarkable for the different structural and faunal characters they present in different localities. Upon these variations have been based the division of these beds into three horizontal areas, called respectively, the *west*, the *central*, and the *east*. The west is characterised by its sands and mottled clay, and is developed round Reading and in the Isle of Wight; in the central area the Woolwich series is represented by pebble-beds, sands, and laminated clays, and occupies the district round Woolwich, Blackheath, and Bromley; and the east area is marked by the quartzose and glauconiferous sands of Herne Bay and the neighbourhood of Canterbury. Looked at from a zoological point of view, the eastern may be distinguished by the marine character of its fauna, the central by its fossils belonging, for the most part, to fluviomarine or estuarine genera, while the district farther west presents freshwater characteristics. In the central area, and immediately north of a line running through Croydon, Hayes, and Orpington, is a district where sands and shingles are largely developed. It might be said that these shingles and sands are non-fossiliferous, were it not that in the midst of them there stands a pit known as the Sundridge Park or Elmstead Lane pit, where the fauna of this period is preserved, and that, too, in great abundance. The strata in this section are exceedingly difficult to trace satisfactorily, in consequence of false stratification. Farther north, as at Charlton, there are one or two sections, the study of which would greatly facilitate the understanding of the pit in Sundridge Park. At Charlton, and most other places where the beds believed to correspond with those we saw, are exposed, the sand is loose; at Sundridge, and at Chiselhurst large portions are hardened into a stone-like mass by a calcareous cement. Indeed, we believe it was for the sake of this stone that the pit was opened, and even now it is occasionally worked. The sand occurs in bands, of from 25 to 30 feet thick, of a hard, light-coloured conglomerate; between them a loose sand intervenes abounding in fossils. It is difficult to say what is the precise position of these strata in the Woolwich series; but Mr. Prestwich believes them to be synchronous with the upper sands at Lewisham and the pebbly sands overlying non-fossiliferous sands at Woolwich.

Amidst the great variety presented by the Woolwich series in its horizontal extent, there occurs one feature which is tolerably constant, and that is the presence of a bed or beds of oysters, made up for the most part of shells of *Ostrea bellovacina*. Such beds occur at a great many places; it will suffice to mention here, Catsgrove Hill, near Reading; in sand, near Hertford; at Woolwich, near Crayford, at Stone, Camberwell, East Dulwich, and Peckham.

But nowhere is this species better developed, as regards the shell part at least, than at Sundridge and Woolwich. These localities together appear to have formed the capital of this kind of Oyster. Generally these Oysters are in a loose sand, but at Sundridge, Plumstead, and Charlton, they are in a coarse limestone, in which the shells are cemented together by a calcareous base. Mr. Prestwich has satisfactorily determined that some of these oyster-beds are on the same zone; but there still remains considerable doubt as to whether the Bromley oyster-bed is coeval with that at Reading, or those which occur out of the London basin, as at Newhaven, in Sussex, and one or two localities in the Hampshire basin. Whether or not they belong to the same time, it would be interesting to know what has given rise to the conglomeration of the Oysters in the central area, and not in the others. At the Sundridge pit several of the members climbed to places which a local paper reports as being "dangerous," and it adds "that the members seemed to be used to that kind of work." A large number of Oysters and Cyrenæ were obtained, and also a few other shells, such as Melanopsis, &c. The Oysters chiefly belonged to the *Bellovacina* species, under which name is included, *O. edulina*, which is scarcely to be distinguished from the modern edible species. In the pit visited by us Cyrenæ occur with the Oysters; but Pectunculi are rare. Mr. Ilott says he does not remember to have seen a single Pectunculus there, but a little farther on they become exceeding plentiful.

A visit was next made to the top of the shaft, situated about the centre of the tunnel, which is now being driven for railway purposes. The ground about this was covered with large heaps of sand, and a hard conglomerate, probably the same as that occurring in the pit.

At Chiselhurst, as already mentioned, black flint pebbles occur in great profusion. They are very uniform in size (varying from about half-an-inch to an inch and a half), highly polished, and water-worn, indicating the long continuance of some powerfully grinding force, in all probability a strong oceanic tide. They are found in small numbers at most localities where the Woolwich beds exist; but the great depositories for them appear to be in the estuarine and fluviatile strata of Woolwich and Bromley. Wherever they are found they are associated with yellow sands. At Blackheath, too, the surface-soil is at places entirely composed of these black stones, from which circumstance, probably, the name is derived. The Whiting Shoal in the Thames is a mass of black stones, embedded in a siliceous base, that is, a true pudding-stone. It would be interesting to know if these stones are in their natural position, or if they have been washed up by the action of the river-currents, and subsequently cemented together. In many places on the south-eastern side of London, the masses of sand and pebbles in the upper part of the Woolwich series are also hardened into a true pudding-stone. This may, perhaps, suggest that the shoal in the Thames may be the relic of these old Tertiaries, in the same way that the Hertfordshire pudding-stone is regarded by some as being the remains of the Woolwich beds in that part of England.

Before quitting this branch of my subject I cannot help hinting that it might be interesting to compare the Bromley beds with the Woolwich strata exposed at Herne Bay and Kyson. At the latter place, I believe, *Ostrea bellovacina* has been found associated with Mammalian remains, such as those of the small Pachyderm, *Hyracotherium cuniculus*, and a species of Bat.

Two mineralogical facts may be here alluded to. The one is the existence of a hydrated silicate of alumina, or allophane, in the face of the railway-cuttings. It was, I think, first found in this country in 1856, at the Charlton pit, by Professor Morris. It there occurs in the fissures of the Chalk, and from the circumstances presented, is believed by Professor Morris to have originated from the action of water on the overlying Woolwich beds. At the Chiselhurst railway-cutting it lines fissures in the Woolwich beds. The brown sandy clay, which is itself a hydrated silicate of alumina, only impure, appears to have been transmuted into allophane, which is here of a pure white colour like chalk, and of a dull earthy structure. At Charlton its colour is no doubt different, since the workmen know it by the name of "petrified water." At other places on the Continent it is blue, and a number of other tints, from which variation of colour or appearance it derives its name allophane. When ordinary clay is breathed upon, it emits a strong characteristic odour; but with the allophane this odour is scarcely, if at all, distinguishable. A few experiments on these two substances might, therefore, throw some light on the question as to what is the cause of the odour of clay. This odour, by-the-bye, I find is very perceptible on the oyster-shell, although there is no trace of clay about it, and the specimen was imbedded in a fine whitish sand, stained with a little oxide of iron. For other details on this point I would refer you to a paper on the Plasticity and Odour of Clay, by Mr. Tomlinson, contained in No. 8 of our Proceedings, where an experiment is made in which this odour is referred to the presence of sesquioxide of iron.

The other mineralogical fact is that the mottled clay has a considerable proportion of gelatinous or soluble silica, that is, silica which can be dissolved in alkaline solutions without the application of heat. Since, then, it actually exists in this form in the Tertiaries, it is possible that it may have existed in this form in the Cretaceous period. Indeed it occurs in beds older than the Chalk, namely, in the Lias, and in beds between the Gault and the Chalk. This note scarcely belongs to my subject, but I have mentioned it because, on the hypothesis of the existence of the gelatinous silica during the deposition of the Chalk, we may perhaps understand how shells can have become imbedded in flint. Several excellent examples of such shells were shown to the excursionists. Many other subjects occupied the attention of the party, and the success of the excursion was mainly attributable to the exertions and hospitality of Mr. Ilott.

Ordinary Meeting, November 1*st*, 1864.

Professor Tennant, F.G.S., Vice-President, in the Chair.

The following papers were read:—

1st. "On Metamorphism in certain Strata at Bendigo, Australia." By Mr. R. Lechmere Guppy.

Among the many remarkable phenomena met with in the gold-fields of Australia, and which have scarcely yet received the attention they seem to deserve, there is one of which I shall attempt to give a short description.

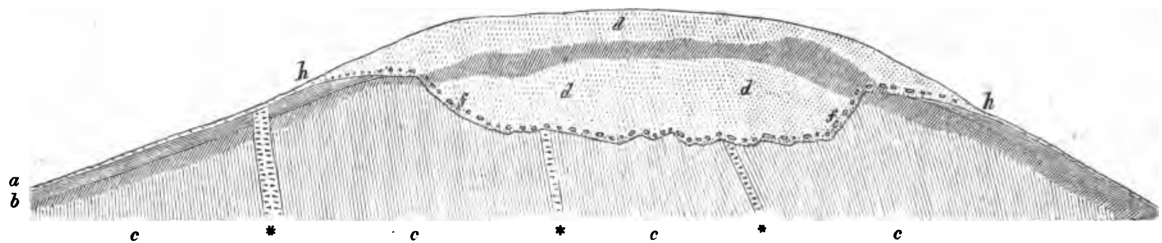
At the south-eastern corner of the great gold-field of Bendigo in Victoria, there is a remarkable range of auriferous hills, known as the "White Hills." These hills are numbered respectively from first to seventh, though there is a small hill at the commencement of the series which is not taken into account in this enumeration. The gold-bearing deposit runs through these hills without interruption; for every portion of ground within the limits of the auriferous band, whether the deposit yielding the metal exhibits itself superficially on the hill-sides, or at some depth in the gullies and the upper portions of the hills, has been profitably worked.

I shall now describe the ideal section which I have constructed for the elucidation of the phenomena; I say *ideal*, because it is not drawn from actual admeasurement, nor to any particular scale; but it may be taken as a pretty fair representation of the conditions of the deposits forming the White Hills.

The lowest stratum represented in the drawing at p. 411 is a pipe-clay, (*c*) usually white and pure, but in some places red and yellow, and in others sandy. It is, in general, finely laminated, and it is intersected by veins or dykes of quartz, in a direction parallel to its lamination. Upon the pipe-clay, which is called the "*bottom*," is superimposed the gold-bearing stratum of quartz gravel. This stratum is distinguished in the middle or upper portions of the hill by large, sometimes immense, quartz boulders and pieces of sandstone and pipe-clay. This auriferous layer is thickest towards the "*dips*," as at *f* in the drawing. It is usually not more than a foot in thickness, sometimes even not more than two inches, but in the *dips* it sometimes exceeds twelve feet. It only differs from the other layers of gravel (*d*) above it in that the latter are composed chiefly of smaller pebbles, and have little or none of the pipe-clay. The gravel is deposited in layers of varying degrees of coarseness up to the surface, where there is a slight mixture of vegetable earth.

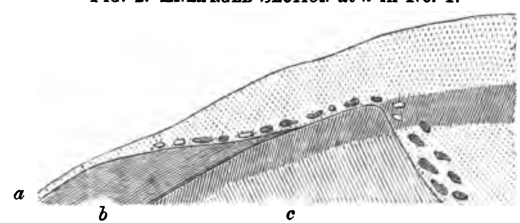
But an irregular layer or mass of indurated gravel is invariably met with in sinking shafts in the White Hills. This mass, represented in the drawing by the oblique shading, does not differ, except as to hardness, from the other portions of the gravel-beds, and bears no relation to the stratification. When we follow this indurated gravel to the margins of the hill, where the *bottom* comes near to the surface, we lose it, and we find that the pipe-clay

FIG. 1. DIAGRAM-SECTION OF A "WHITE HILL," BENDIGO, VICTORIA.



a Surface-soil, auriferous; the quartz usually angular. *b* Red, yellow, and mottled clays. *c* White pipe-clay. *d* Quartz-pebbles and sand. * Quartz-veins or Reefs. The indurated portions are expressed by oblique shading, thus 

FIG. 2. ENLARGED SECTION at *h* in No. 1.



becomes indurated; and that first, as we proceed in a direction away from the middle of the hill, we find that the gold-bearing gravel, superimposed upon the indurated pipe-clay, is also indurated; then we find a gradual interposition of softer white and mottled clays, between the auriferous gravel and the indurated pipe-clay, until they are some feet apart. Upon the softer clay, which now becomes the *bottom*, we find softer red and mottled clayey gravels for our "*washing-stuff*," as the auriferous stratum is termed. At the point marked in the diagram by the letter *h* we find the *bottom* to be red clays, descending into yellow and mottled clays, the gold-bearing stratum being angular quartz gravel, mixed with humus, but rarely having large boulders of quartz. I should remark that the gravel above the "*cement*," as the indurated gravel is locally termed, is usually more or less clayey and red.

Having given a brief description of the section, I will now proceed to suggest an explanation of part of the phenomena. It will be noticed, that the quartz-reef on the left of the section is represented as coming up through the indurated pipe-clay, and through the red and mottled clays. The surface-deposit of auriferous gravel rests upon the edge of the quartz-dyke in the same manner as upon the red clays, where the latter constitute the *bottom*. It is evident therefore, that if the quartz-dyke belongs to the same formation as the pipe-clay, that the red and mottled clays also belong to the same formation; in fact, that they are a part of the same deposit. Now, it is evident, from the fact that induration passes through all the layers alike of clay or gravel that have come within the sphere of its action, that that state was induced subsequently to the deposition of all the strata; yet we find no red clay below the indurated gravel. Now, I think it follows that the red clay must have been deposited prior to the induration; and if so, it was probably in the state of white pipe-clay. It, therefore, appears that some action must have taken place in all those parts of the deposit of originally white pipe-clay which were not covered by the *cement*, and that this action must have been most intense at the surface, in such a manner as to cause the upper part of the pipe-clay to have become of a deep red colour, gradually lightening downwards into pink, mottled, and yellow, and finally white clays, which lie directly on the indurated pipe-clay. What the nature of the action was that caused the induration I cannot conjecture; nor why it should have happened that a complete cover at the depth of six or eight feet below the surface all over these hills has been formed of the indurated materials, whether pipe-clay or conglomerate. As I have shown that it is quite irrespective of the nature of the stratum it has taken place in, it would be impossible to suppose that there had been two or more deposits of gold—one prior to, for instance, and others subsequent to the induration; for in such a case we should find gold all along above the surface of the indurated material, whereas we only find it on the *bottom*, be that soft pipe-clay, indurated pipe-clay, or red clay. In any case the phenomena are so remarkable as to deserve in a high degree the attention of geologists and mineralogists.

There are two points worthy of investigation. First, the cause which led to the induration of the masses in so remarkable a manner; and, second, the causes of the change from white pipe-clay to red clay.

As far as my observations have extended, they have not thrown any light upon these causes. I have only been able to arrive at the conclusion that the causes were irrespective of the deposition of the strata, and that that which led to their induration operated at a depth of a few feet only below the surface. The sequence of events was in this wise. After the deposition and solidification of the pipe-clay, a large quantity of gravel was deposited above it, probably by fresh-water action. Subsequently to this there occurred an action of induration, taking place at a depth of several feet below the surface, leaving untouched the superficial portions of the deposits. Then there occurred a metamorphism of the pipe-clay, and perhaps a corresponding change, but in a less marked degree, in the gravels resting on the portions wherein induration had taken place. This metamorphic action reduced the part of the pipe-clay affected by it to a state of red and mottled clays, less compact than the original material.

I do not, however, overlook the possibility that these two actions might have been synchronous, and may, in fact, have been one the cause of the other. It is possible that the draining-out of certain constituents of the superficial portions into those immediately beneath them may have caused the metamorphism of the superficial and the induration of the inferior portions.

I do not know of the existence of organic remains in any of the strata, with the exception of the anomalous worm-burrowings in the red and mottled clays, which were described by me in a paper read to the Geologists' Association, and which will be found in vol. 1 of the Proceedings, p. 161.

2nd. "On the Uneven Surface of the Chalk when covered by Boulder-clays and Gravel." By Mr. A. Bott, F.G.S.

Ordinary Meeting, December 6th, 1864.

E. Cresy, Esq., President, in the Chair.

A Paper was read by Mr. C. Tomlinson, F.C.S., entitled 'Two Days on the Chesil Bank,' in which he described a visit to that remarkable bank of shingle, the most extensive in Europe, extending, as it does, from Burton Cliff, near Bridport, to the Isle of Portland, a distance of nearly nineteen miles. Mr. Tomlinson did what few visitors to this part of our coast care to do: he walked the whole length of the Bank, which in the last ten miles has no other path than the loose shingle. He also collected (and exhibited) pebbles from different parts of the Bank, not only to illustrate their species, but also the remarkable and gradual increase in size, from blown sand, at Burton Cliff, to pebbles of the size of turnips, at the village of Chesil. Among the pebbles, those of rolled flint or of translucent quartz are most abundant: there were also pebbles of black fullers' earth, black Devonian Limestone, Old Red Sandstone, Porphyry with green and red spots, Lias with lines of carbonate of lime, forest-marble, and jasper. Parts of the Bank are broken into gulleys by the infiltration of water, and the subsequent hydrostatic pressure during heavy seas. A large map of the locality, and diagrams showing the dimensions of the Bank, as determined by Mr. Coode, the Engineer of the Portland Breakwater, were exhibited. The questions then discussed by Mr. Tomlinson were—1. Where do the pebbles come from? 2. What force transferred the pebbles from a distance? 3. What force retains them in their present position? 4. Why do the largest pebbles travel to the greatest distance? Mr. Coode's investigations were several times referred to, as well as those of Mr. Palmer and others, on moving shingle, and the importance to the Engineer of ascertaining the laws which govern it.

After the reading of the paper, a lively discussion followed, in which a large number of the Associates took part. The President summed up, and Mr. Tomlinson replied at some length. He recommended that one of the next Summer-trips of the Association should be to the Chesil Bank, and that in the meantime a Committee should be appointed to draw up instructions for the visitors as to what points require to be carefully examined before all the questions raised on the subject could be considered as settled.

Conversazione, *January* 24*th*, 1865.

A Conversazione was held on Tuesday, January 24th, in the rooms of the Association, at which about a hundred of the Members and their friends were present. A large number of interesting fossils were exhibited by Mr. Pickering, Mr. Evans, Mr. Bott, and Mr. Meijer, and a collection of minerals, from Germany, by Mr. G. E. Roberts, this latter being the chief centre of attraction to those present. It consisted of, perhaps, the finest collection of quartz, felspar, and lime crystals which has ever been exhibited in this country. Microscropes and objects were kindly lent and managed by Mr. Hislop, Mr. Leighton, and Mr. Ramsey. During the evening, Mr. Highley, F.G.S., exhibited by the aid of the oxyhydrogen light a series of micro-photographs, illustrative of geology and its allied sciences; and Mr. T. Boverton Redwood, read a paper "On the metal magnesium," and exhibited in great perfection the light produced by its combustion.

Coffee was served at ten o'clock, and the Members and their friends did not separate till eleven o'clock.

"On the Metal Magnesium." By Mr. T. BOVERTON REDWOOD.

THIS metal, which has of late attracted considerable attention on account of the brilliant light afforded by its combustion, is an abundant element of the crust of the earth, but is never found in an uncombined or metallic state.

Combined with oxygen it constitutes the well-known alkaline earth, magnesia. Dolomite, or magnesian limestone, consists of a double carbonate of magnesia and lime. Steatite or soap-stone, meerschaum, of smoking celebrity, asbestos, and talc also all consist mainly of magnesia in combination with silica.

It is contained abundantly in sea-water, partly as sulphate of magnesia, but principally as chloride of magnesium. Sulphate of magnesia is also found in many mineral springs, such as those in the neighbourhood of Epsom, from which circumstance it has acquired the name of Epsom Salts; but although this well-known medicine was originally derived from Epsom waters, it is now principally prepared from magnesian limestone or dolomite in the following manner. The limestone is first burned, slaked, and washed with water to remove part of the lime which is associated with the magnesia in the mineral; it is then treated with sulphuric acid, and the sulphate of magnesia separated from the sulphate of lime by solution and recrystallisation.

From solution of sulphate of magnesia, carbonate of magnesia is prepared by precipitation with solution of carbonate of soda; and from the carbonate, chloride of magnesium is produced by dissolving the former in hydrochloric acid, adding some chloride of ammonium, evaporating the mixture to dryness, and fusing the residue at a red heat; under these circumstances the chloride of ammonium is volatilised and the chloride of magnesium remains in a fused state. This is the source from which metallic magnesium is now obtained.

Metals are usually reduced by heating one of their compounds to a high temperature in contact with carbon, but this method could not be adopted in the case of magnesium, for the high temperature necessary for the reduction would cause the metal to burn and recombine with oxygen as soon as produced.

Sir Humphry Davy, who has the credit of having first demonstrated the existence of magnesium as a chemical element, effected its separation from magnesia by means of electricity.

On the 6th of October, 1807, Davy commenced a series of experiments, remarkable for the results obtained, which ended in the discovery, amongst other metals, of magnesium.

He placed a small piece of potash or soda upon a platinum plate connected with the negative pole of a powerful galvanic battery, and brought into contact with it a platinum wire connected with the positive pole.

Under these circumstances the alkali became decomposed, effervescence occurred, and globules having a high metallic lustre were obtained. These globules were found to consist of the metallic base of the alkali; potash yielding the metal which is now called potassium, and soda yielding sodium. The metals were also obtained by treating, as above, either of the alkalies, previously mixed with oxide of mercury, but in this case the product consisted of a crystalline amalgam.

On substituting lime, magnesia, or any one of the alkaline earths for the potash or soda, amalgams of the metals calcium, magnesium, &c., were formed, though in much smaller quantity than in the preceding case; but when metallic mercury was used instead of its oxide, the amalgams were produced with facility.

It now only remained, theoretically, to heat the amalgams in a tube, for the mercury to be driven off, leaving the metals in a pure state, but practically it was found impossible to separate the whole of the mercury, and it was not until the year 1829 that pure magnesium was produced by Bussy, although its existence had been previously demonstrated. The method adopted by this chemist consisted in decomposing chloride of magnesium with metallic potassium. The metal thus produced was in the form of a grey powder, which could be fused into globules.

Bunsen prepares magnesium by the electrolytic decomposition of chloride of magnesium.

The salt is fused in a porcelain crucible divided by a vertical diaphragm which extends half way down the crucible, while carbon points (electrodes) connected with the ends of a galvanic battery, are introduced, one on each side of the diaphragm, through two openings in the lid of the crucible.

The negative electrode is notched to receive the reduced magnesium, which lodges in the cavities, and is collected there, while the chlorine escapes at the positive electrode.

Deville, of Paris, whose name is so intimately associated with the practical processes by which the metal aluminum is produced on a manufacturing scale, together with Caron obtain the metal as follows:—9,000 grains of pure chloride of magnesium are mixed with 1,500 grains of fused chloride of sodium, and 1,500 of pure fluoride of calcium, both in fine powder; 1,500 grains of sodium in small fragments are carefully mingled with the powder, and the whole is thrown into a clay crucible at a full red heat, and it is then instantly covered.

When the mixture has become tranquil, the cover is removed, and the fused mass is stirred with an iron rod in order to render it homogeneous throughout, and to obtain a clear surface upon the liquid. Globules of magnesium are then distinctly visible. The crucible is allowed to cool partially, and the metallic particles are united by means of an iron rod; the melted mass is then poured upon a shovel, and the magnesium, amounting to about 675 grains, is separated from the clay. Magnesium is at present manufactured by a process lately patented by Mr. Sonstadt, which is similar to the one just described; the principal difference consisting in the employment of an iron instead of a clay crucible. Magnesium presents the appearance of a brilliant, silver-white metal, which is somewhat brittle at ordinary temperatures, but malleable at a heat below redness. It fuses and distils about as easily as zinc. It is little oxidisable at ordinary temperatures, even in moist air, but when heated to redness it takes fire, burning with an extremely brilliant white light, and producing magnesia. Its sp. gr. is 1·743 (not quite twice as heavy as water) and its hardness is equal to calc-spar.

For purposes of combustion it is forced into wire by pressing it in a heated steel press, having a fine opening at the bottom. The wire thus produced is sometimes flattened into ribbon. It can be burnt, either as wire, or in the state of ribbon by holding it, at an angle of 45°, in a spirit-lamp flame, but a preferable method consists in the use of a lamp such as was employed by the writer in exhibiting the light produced by the combustion of the metal. This apparatus * consists of a small metallic box, containing

* Made by Mr. Solomon, of 22, Red Lion Square.

two india-rubber-covered rollers, which are turned by clockwork. On pushing one end of a piece of wire or ribbon through an aperture provided at the back of the box, it comes into contact with the revolving rollers, is drawn in, and pushed forward through a tube terminating in front of a concave mirror, where it is burnt. On the top of the lamp are two fan arms in connection with the clockwork, and by turning these so as to expose more or less resistance to the air, the speed at which the wire is delivered can be easily regulated. The mirror is sometimes provided with a glass front, and a chimney to carry off the magnesia produced by the combustion, which additions are indispensable if the apparatus is used in a current of air. In lighting the lamp, it is only necessary to apply the flame of a lighted taper to the wire as it issues from the tube in front of the mirror. Provided that the rate of delivery of the wire is properly adjusted, it will continue burning until the supply is exhausted or the clockwork ceases to revolve.

In 1859 Professors Bunsen and Roscoe determined that a burning magnesium wire of the thickness of 0·297 millemetre evolves, according to their measurement, as much light as 74 stearine candles, of which five go to the pound. If this light lasted one minute, 0·987 metre of wire, weighing 0·120 gramme would be burnt. In order to produce a light equal to 74 candles, burning for ten hours, whereby about twenty pounds of stearine is consumed, 72·2 grammes of magnesium would be required. The same chemists also found the light to be extremely rich in chemically active rays, due partly to the incandescent vapour of magnesium, and partly to the intensely heated magnesia formed by the combustion. The intensity of the light produced, its richness in violet and ultra-violet rays, upon which the chemical action of light depends, and the facility with which it is produced, suggested its application to photography. This application has proved perfectly successful, and the magnesium-light is now used for taking photographic pictures, at night, in foggy weather, or in places where the direct light of the sun cannot be obtained.

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